Chapter 4
Environmental Impacts

4.1 ENVIRONMENTAL IMPACTS

This chapter describes the environmental impacts of each alternative, based on the alternatives descriptions in Chapter 2 and the Affected Environment discussion in Chapter 3. These impacts are summarized in Table 2.4-1.

For comparison purposes, emissions values and other impact measures are presented with their appropriate regulatory standards or guidelines. However, compliance with regulatory standards does not necessarily indicate the significance or severity of environmental impacts for purposes of the *National Environmental Policy Act* (NEPA) of 1969.

4.2 LAND USE/VISUAL RESOURCES

4.2.1 NO ACTION ALTERNATIVE

Under this alternative the facility would remain in its present state. Consequently, there would be no impacts on current land use or visual resources, either on a regional or site-specific level.

4.2.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

Under this alternative there are no plans to modify the exterior appearance of the HFBR. Operation of the facility would not result in a visible plume from the existing stack. Consequently, there would be no impacts on current land use or visual resources, either on a regional or site-specific level.

4.2.3 RESUME OPERATION ALTERNATIVE – 60 MW POWER LEVEL

Under this alternative there are no plans to modify the exterior appearance of the HFBR. Operation of the facility would not result in a visible plume from the existing stack. Consequently, there would be no impacts on current land use or visual resources, either on a regional or site-specific level.

4.2.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

Upgrading the HFBR could result in changes to the interior of the current building. However, the implementation of these upgrades would not change the current land use nor would it affect the visual characteristics of the BNL facility as a whole. Therefore, it is unlikely that the current land use and visual resources would be impacted as a result of upgrading the facility. During construction, particulate emissions could temporarily affect visibility in localized areas, but would not exceed Federal or State requirements (see Section 4.4). Operation of the facility would not result in a visible plume from the existing stack.

4.2.5 PERMANENT SHUTDOWN ALTERNATIVE

Under this alternative the reactor would be placed in an industrially and radiologically safe condition for eventual D&D. The current land use and visual resources of the HFBR site would not be changed. The area would remain industrial/commercial. Consequently, there would be no impacts on current land use or visual resources, either on a regional or site-specific level.

4.3 INFRASTRUCTURE

This section discusses the change in resource requirements imposed by the HFBR DEIS alternatives. Infrastructure impacts are assessed by overlaying the support requirements of the various alternatives on the existing BNL infrastructure capacities. These impact assessments focus on the requirements for electrical power, water, steam, and land. Table 4.3-1 identifies the infrastructure requirements for the HFBR DEIS alternatives.

4.3.1 NO ACTION ALTERNATIVE

The No Action Alternative represents the baseline HFBR infrastructure characteristics to which the other alternatives are compared. These baseline infrastructure requirements would result in no significant adverse impacts on BNL infrastructure requirements. The baseline HFBR electrical and steam usage are 2 percent of BNL electrical and steam usage. The baseline HFBR water usage is only 1 percent of BNL water usage. These baseline HFBR electrical, steam, and water requirements are well within BNL's historic usage and infrastructure capacity.

4.3.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

Resuming operation of the HFBR at a power level of 30 MW would result in no significant adverse impacts on BNL infrastructure requirements. Although HFBR electrical and steam usage for the HFBR would increase (from 4,000 MWh/yr to 14,000 MWh/yr for electrical usage and from 4.5×10^6 kg/yr to 1.1×10^7 kg/yr for steam usage; see Table 4.3–1) in comparison to the No Action Alternative, this represents only a small increase (5 percent and 2 percent, respectively) in BNL site electrical and steam usage (See Table 3.3–1). Although HFBR water usage would increase from the 0.2 MLD baseline to 1.4 MLD (see Table 4.3–1), the increase would represent a 9 percent increase in BNL water usage and bring BNL water usage to only about 67 percent of BNL water treatment plant capacity. These increases in electrical, steam, and water requirements are well within HFBR's and BNL's historic usage and existing infrastructure capacity.

4.3.3 RESUME OPERATION ALTERNATIVE – 60 MW POWER LEVEL

Resuming operation of the HFBR at an initial power level of 30 MW and then increasing to an operating power level of 60 MW would result in no significant adverse impacts on BNL infrastructure requirements. Although HFBR electrical and steam usage for the HFBR would increase (from 4,000 MWh/yr to 14,000 MWh/yr for electrical usage and from 4.5×10^6 kg/yr to 1.5×10^7 kg/yr for steam usage; see Table 4.3–1) in comparison to the No Action Alternative, this represents only a small increase (5 percent and 4 percent, respectively) in BNL electrical and steam usage (see Table 3.3–1). Although HFBR water usage would increase from the 0.2 MLD baseline to 2.8 MLD (see Table 4.3–1), the increase would represent an 18 percent increase in BNL water usage and bring BNL water usage to only about 73 percent of BNL water treatment plant capacity. These increases in electrical, steam, and water requirements are well within HFBR's and BNL's historic usage and existing infrastructure capacity.

4.3.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

Resuming operation and enhancing the HFBR is operationally identical to operating the HFBR at a power level of 60 MW which has been shown to result in no significant adverse impacts on site infrastructure requirements, as discussed previously in Section 4.3.3. During the enhancement phase, which could be compared to a construction phase or a major maintenance activity, it is expected that the requirements for electrical, steam, and water service would increase in comparison to the No Action Alternative. Although the specific infrastructure requirements have not been estimated for the enhancement phase, it is expected that the requirements for electrical, steam, and water service during this phase would be no more than what is required during operation at a power level of 60 MW.

4.3.5 PERMANENT SHUTDOWN ALTERNATIVE

Terminating the scientific mission of the HFBR and maintaining the reactor in an industrially and radiologically safe condition would equate to the reactor being maintained in a long-term surveillance and maintenance (S&M) condition. The nature of long-term S&M is almost identical to the activities performed currently for the shutdown (defueled HFBR) and therefore, the infrastructure requirements of this alternative are expected to be about the same as the infrastructure requirements for the No Action Alternative for which there would be no significant adverse impacts.

Table 4.3-1. Impacts of Alternatives on HFBR Infrastructure

Infrastructure Characteristics	No Action (Current Mode)	Resume Operations Start at 30 MW		Resume Operations Increase to 60 MW		Enhance Facility and Operate at 60 MW		Permanent Shutdown	
		Value	% Change	Value	% Change	Value	% Change	Value	% Change
Land									
Developed HFBR Area (ha)	4	4	0%	4	0%	4	0%	4	0%
Site Roads (km)	70	70	0%	70	0%	70	0%	70	0%
Site Railroads (km)	2.7	2.7	0%	2.7	0%	2.7	0%	2.7	0%
Electrical									
Energy Consumption (MWh/yr)	4,000[b]	14,000[g]	250%[h]	14,000[g]	250%[h]	14,000[g]	250%[h]	4,000	0%
Peak Load (MWe)	0.5[c]	3.1	520%[h]	3.1	520%[h]	3.1	520%[h]	0.5	0%
Steam									
Usage (kg/yr)	4.5×10^{6} [d]	1.1×10^{7}	147%[i]	1.5×10^{7}	233%[l]	1.5×10^{7}	233%[i]	4.5×10^{6}	0%
Peak Demand (kg/s)	0.76[e]	1.01	33%[j]	1.01	33%[j]	1.01	33%[j]	0.76	0%
Water									
Usage[a] (MLD)	0.2[f]	1.4	600%[k]	2.8	1300%[m]	2.8	1300%[m]	0.2	0%

[a] An estimated 0.02-0.08 MLD of water is used as makeup water to the air conditioning cooling towers. The majority (65-75%) is evaporated in the towers. 25-35% is discharged as system “blowdown” to the sanitary system. Air conditioning loads increase during reactor operating conditions but the range of water consumption is primarily caused by seasonal variations in air conditioning loads.
[b] This represents 2% of BNL’s current consumption.
[c] This represents 1% of BNL’s current consumption.
[d] This represents 2% of BNL’s current usage.
[e] This represents 3% of BNL’s current capacity.
[f] This represents 1% of BNL’s current usage and 0.3% of BNL’s current capacity.
[g] Energy consumption includes operation of the Cold Neutron Facility.
[h] This represents a 5% increase in BNL’s current consumption.
[i] This represents a 2% increase in BNL’s current usage.
[j] This represents 1% of BNL’s current capacity.
[k] This represents a 9% increase in BNL’s current usage and 5% of BNL’s current capacity.
[l] This represents a 4% increase in BNL’s current usage.
[m] This represents an 18% increase in BNL’s current usage and 11% of BNL’s current capacity.
Source: BNL 1995; BNL 1998a; BNL 1998b; Ports 1998a

4.4 AIR QUALITY/NOISE

4.4.1 NO ACTION ALTERNATIVE

4.4.1.1 Air Quality

Under the No Action Alternative, the HFBR would remain shutdown and modifications and repairs to the facility completed. Analysis of the potential impacts to air quality for this alternative considered air pollutant emissions from the HFBR in shutdown mode including those resulting from clean up of the existing HFBR facilities.

Implementation of this alternative would primarily result in dust generated from environmental restoration construction equipment, through the building heating, ventilation, and air condition (HVAC) systems, and vehicle exhaust from employee travel and during routine deliveries.

4.4.1.2 Noise

HFBR environmental investigation and restoration activities would require the drilling of characterization wells. The equipment required to perform these activities would generate noise in the areas surrounding the HFBR. At the BNL boundary, the noise levels would be barely distinguishable from background noise levels. For example, the noise level 15 m (50 ft) from a drill rig would be about 90 dB. At a distance of 1.6 km (1 mi), the noise level would be 50 dB, and at a distance of 3.2 km (2 mi), the noise level would be about 44 dB. Since background sound levels are estimated at 50 dB for the main BNL facility (BNL 1994), there would essentially be no increase in noise levels at the facility boundary.

Noise levels related to HFBR shutdown operations would continue at current levels, since the most significant reduction resulted from the cessation of cooling tower operations. All interior noise would be mitigated since the auxiliary equipment and experimental facilities are housed in the HFBR's welded steel hemispherical structure.

4.4.2 RESUME OPERATION ALTERNATIVE - 30 MW POWER LEVEL

4.4.2.1 Air Quality

Since the HFBR would use heavy water to cool the reactor and moderate neutrons used in the fission process, the primary air quality issue involves radioactive emissions which are covered in Section 4.11.

Nonradioactive emissions would be generated in small quantities from laboratory equipment, HVAC systems, and vehicle exhaust during routine deliveries. In addition, the reactor, its auxiliary equipment, and its experimental facilities are housed in a welded steel hemispherical structure, 54 m (176 ft) in diameter. During routine reactor operations, the air pressure inside this building would be kept slightly lower than atmospheric pressure outside to ensure that any air movement is inward rather than outward. Access to the building is through air locks. Moreover, exhaust air is filtered through high efficiency filters prior to being released through the stack. The emissions from these activities would not be of consequence to offsite air quality. Thus, air quality would not be substantially affected by resuming HFBR operations at the 30 MW power level.

4.4.2.2 Noise

Noise emissions from operating the HFBR at 30 MW power level would be largely related to operating process equipment (for example, heaters, coolers, generators, and experimental equipment), environmental restoration construction equipment, employee vehicle traffic, routine deliveries, and the cooling towers. Because the process and experimental equipment for the facility would be operating inside enclosed structures, exterior noise levels would not be increased. There would be some exterior noise emissions from the adjoining cooling tower, however, noise levels at the HFBR would be minimal and would not produce any noise impacts offsite. Overall traffic noise levels on the LIE would be affected less than 3 dB. Noise impacts related to environmental restoration activities would be the same as the No Action Alternative. Thus, noise impacts related to HFBR operations at the 30 MW power level would be considered minor.

4.4.3 Resume Operation Alternative - 60 MW Power Level

4.4.3.1 Air Quality

The air quality impacts from the 60 MW power level would be similar to those described for the 30 MW power level operating scenario. Potential changes in radiological emissions are presented in Section 4.11.

4.4.3.2 Noise

The noise levels generated as a result of the 60 MW power level would be similar to those described for the 30 MW power level operating scenario.

4.4.4 Resume Operation and Enhance Facility Alternative

4.4.4.1 Air Quality

In addition to the air quality impacts mentioned in the Resume Operation Alternatives at 30 MW and 60 MW power levels, new facility construction activities would cause temporary, minor increases in dust. However, the use of standard dust-suppression techniques would mitigate this impact. Overall, particulate emissions during construction could possibly affect visibility temporarily in localized areas but would not exceed Federal or State requirements.

4.4.4.2 Noise

In addition to the noise impacts mentioned in the Resume Operation Alternatives at 30 MW and 60 MW power levels, facility enhancement activities could generate noise levels consistent with light industrial activity and environmental restoration activities. These noise emissions would not be expected to propagate offsite at levels that would affect the general population. The noise emissions of this alternative would depend on the types and number of pieces of mechanized equipment in use at a given time and location, and on the duration of enhancement activities. Noise emission levels from all mechanized equipment used during these activities would be within the OSHA specifications (29 CFR 1910.95(a) (b) and (c) of the OSHA Occupational Noise Exposure Standard). DOE would comply with these measures.

4.4.5 Permanent Shutdown Alternative

4.4.5.1 Air Quality

Air quality impacts related to radioactive emissions are discussed in Section 4.11.

4.4.5.2 Noise

Noise levels related to HFBR shutdown operations would continue at current levels, since the most significant reduction resulted from the cessation of cooling tower operations.

4.5 WATER RESOURCES

4.5.1 NO ACTION ALTERNATIVE

4.5.1.1 Surface Water

Under the No Action Alternative, the HFBR would continue in its shutdown mode. The only potential impact to surface water is from discharge of sanitary waste from the HFBR to the Peconic River via the STP (see Section 3.5.2.3). That rate of discharge is currently estimated to be 0.15 MLD (40,000 GPD) (Ports 1998a). In 1997, the most recent year for which data has been compiled in the *Site Environmental Report*, the average annual tritium concentration at the STP Peconic River outfall was 1,366 pCi/ℓ which is 7 percent of the SDWA standard (20,000 pCi/ℓ)(BNL 1999). Therefore under the No Action Alternative, no exceedence of the regulatory criterion for tritium in surface water would be expected.

4.5.1.2 Groundwater

As discussed in Section 2.3, regardless of the alternative selected by DOE, specific modifications will be conducted at the HFBR in order to conform with the requirements of Suffolk County Sanitary Code, Articles 7 and 12 for the protection of groundwater. Following implementation of these modifications to HFBR systems, the entire facility will be in conformance with Articles 7 and 12, and no impacts to groundwater would be expected from these modified systems (for example, the spent fuel pool) under any of the alternatives.

The above modifications do not include the sanitary system connecting the HFBR to the STP (including sanitary piping beneath the HFBR floor). Therefore, under the No Action Alternative, potential impacts to groundwater could result from leakage from the sanitary system. Although this system was eliminated as a principal contributor to the existing tritium plume, a leak test conducted in November 1997 measured a system loss rate of approximately 15 ℓpd to 26 ℓpd (4 GPD to 7 GPD) (BNL 1998e). While the leak rate from the sanitary system sewer line appears comparable to the former leak from the spent fuel pool (23 ℓpd to 34 ℓpd [6 GPD to 9 GPD]), the average annual tritium concentrations are extremely different. In 1996, the average annual tritium concentration at the discharge from the HFBR sanitary system was about 7,100 picocuries/ℓ (pCi/ℓ). This concentration is about one-third of the Safe Drinking Water Act (SDWA) standard of 20,000 pCi/ℓ that is established by the EPA for protection of human health. The average spent fuel pool tritium concentration was about 40,000,000 pCi/ℓ, with a noted increase to 140,000,000 pCi/ℓ in 1995. Following further inspections and repairs, additional leak testing of the sanitary system is planned to ensure that the sanitary system integrity satisfies SCDHS building and sanitary code requirements.

It should be noted that the groundwater monitoring network for the HFBR, consisting of underlying horizontal and downgradient vertical wells, would provide early detection of a leak from the sanitary system. Furthermore, the three recovery well system currently operating to collect groundwater from the existing tritium plume could be restarted (assuming that the current tritium release has been remediated) and used to capture contaminated groundwater from any potential leak well before it reached the southern site boundary. The future operation of this remedial system will be determined under the CERCLA actions for OU III.

There are no in-service onsite supply wells located downgradient from the HFBR. Therefore, any leakage from the facility itself would not adversely affect the onsite well supply system.

The *U.S. Nuclear Regulatory Commission Safety Assessment of the High Flux Beam Reactor at the Brookhaven National Laboratory* (NRC 1999) concluded that "actions taken to characterize and control the groundwater tritium plume were conservative, and this tritium plume does not present a radiological hazard to public health or safety. Monitoring and control of effluents at the HFBR were acceptable. Releases were well below the applicable limits and followed ALARA practices."

4.5.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

4.5.2.1 Surface Water

Under the 30 MW Alternative, 0.27 MLD (71,000 GPD) of water from the HFBR would be discharged to the Peconic River via the STP under a SPDES permit (Ports 1998a). The annual average concentration of tritium in the outfall under the 30 MW Alternative is expected to be up to two times the level reported in 1996 (Ports 1998c). The annual average concentration of tritium in the STP outfall in 1996 was 1,348 pCi/l (BNL 1998c). Therefore, under the 30 MW Alternative, the annual average concentration is expected to be up to approximately 3,000 pCi/l, which is 15 percent of the SDWA standard (20,000 pCi/l). Under the 30 MW Alternative, no exceedence of the regulatory criterion for tritium in surface water would be expected.

4.5.2.2 Groundwater

Under the 30 MW Alternative, potential direct impacts to groundwater could result from: (1) leakage from the HFBR sewer lines, (2) leakage from the secondary cooling water system, and (3) groundwater recharge from Recharge Basin HO due to low level tritium in the secondary water system. Each of these potential sources is addressed below.

As discussed under the No Action Alternative, leakage from the sewer lines connecting the HFBR to the STP (including embedded sewer lines below the HFBR floor) is a potential source of groundwater contamination. Under the 30 MW Alternative, tritium levels in the sanitary system are expected to be up to two times the level reported in 1996 (Ports 1998c). Further leak testing of the sanitary system is planned, and an agreement was made with SCDHS to take necessary actions to assure that the sanitary system integrity satisfies building and sanitary code requirements (Ports 1998b).

Leakage from the secondary cooling water system discharging to soil and subsequently to groundwater could also result in potential impacts to groundwater under the 30 MW Alternative. A detailed description of this system is provided in Section 3.5.2.4.2. The average system tritium concentration when the facility is operating is approximately 1,100 pCi/l (Ports 1999). If DOE decides to restart the HFBR, program and equipment changes would be made as necessary to assure: (1) that future operation would continue to be accomplished within all regulatory requirements, (2) that ALARA criteria would be satisfied, and (3) that routine operations would not result in significant environmental impact.

It should be noted that the groundwater monitoring network for the HFBR, consisting of underlying horizontal and downgradient vertical wells, would be used to provide for early detection of any leaks from the above two systems. Furthermore, the three recovery well system currently operating for the existing tritium plume could be restarted (assuming that the current tritium release has been remediated) and used to capture contaminated groundwater from any potential leak before it exits the southern site boundary (Ports 1998b). The future operation of this remedial system will be determined under the CERCLA actions for OU III.

There are no in-service onsite supply wells located downgradient from the HFBR. Therefore, any leakage from the facility would not adversely affect the onsite well supply system.

Under the 30 MW Alternative, discharge to Recharge Basin HO from the HFBR cooling towers would be approximately 0.34 MLD (90,000 GPD) (Ports 1998a). As discussed in Section 4.11, data from 1995 (when the reactor operated at 30 MW) can be used to represent this alternative. As reported in the 1995 *Site Environmental Report*, no radionuclides attributable to BNL operations were detected in Recharge Basin HO in that year (BNL 1996a). Therefore, under the 30 MW Alternative, no exceedence of the regulatory criterion for tritium in groundwater would be expected as a result of discharge to Recharge Basin HO.

4.5.3 Resume Operation Alternative – 60 MW Power Level

4.5.3.1 Surface Water

Under the 60 MW Alternative, 0.33 MLD (86,000 GPD) of water from the HFBR would be discharged to the Peconic River via the STP under a SPDES permit (Ports 1998a). The annual average concentration of tritium in the STP outfall under the 60 MW Alternative is expected to be the same as for the 30 MW Alternative; that is, up to two times the level reported in 1996 (Ports 1998c). Therefore, under the 60 MW Alternative, the annual average concentration of tritium at the outfall is expected to be up to approximately 3,000 pCi/l, which is 15 percent of the SDWA standard (20,000 pCi/l). Under the 60 MW Alternative, no exceedence of the regulatory criterion for tritium in surface water would be expected.

4.5.3.2 Groundwater

Under the 60 MW Alternative, impacts to groundwater could potentially result from the same three sources identified for the 30 MW Alternative: (1) leakage from the HFBR sewer lines, (2) leakage from the secondary cooling water system, and (3) groundwater recharge from Recharge Basin HO.

Impacts to groundwater from potential leaks from the HFBR sewer lines and the secondary cooling water system under the 60 MW Alternative would be similar to those under the 30 MW Alternative as the expected concentration of tritium in any such leaks would be approximately the same (Ports 1998b; Ports 1998c). As discussed in Section 4.5.2.2, further leak testing of the sanitary system is planned. Furthermore, the groundwater monitoring network already in place for the HFBR would be used to provide for early detection of leaks. In addition, the three recovery well system currently operating for the existing tritium plume could be restarted (assuming that the current tritium release has been remediated) and be used to capture contaminated groundwater from any potential leak before it exits the southern site boundary (Ports 1998b). The future operation of this remedial system will be determined under the CERCLA actions for OU III.

There are no in-service onsite supply wells located downgradient from the HFBR, therefore any leakage from the facility would not adversely affect the onsite well supply system.

Under the 60 MW Alternative, discharge to Recharge Basin HO from the HFBR cooling towers would be approximately 0.74 MLD (195,000 GPD) (Ports 1998a). When the reactor was most recently operating at 60 MW, in 1988, water from the cooling towers discharged to the onsite recharge basins (including Basin HO) contained only trace quantities of tritium, well below the SDWA standard (20,000 pCi/l) (BNL 1989). Therefore, under the 60 MW Alternative, no exceedence of the regulatory criterion for tritium in groundwater would be expected as a result of discharge to Recharge Basin HO.

4.5.4 Resume Operation and Enhance Facility Alternative

Under this alternative, DOE would implement various enhancements and operate the facility at up to 60 MW. Potential impacts to surface water and groundwater resulting from operation under this alternative would be similar to those discussed in Section 4.5.3 for the 60 MW Alternative. Since the reactor would not be operating during facility upgrade activities, there would be a temporary reduction in discharge of water to Recharge Basin HO.

4.5.5 PERMANENT SHUTDOWN ALTERNATIVE

4.5.5.1 Surface Water

Under the Permanent Shutdown Alternative (prior to D&D), discharges to the Peconic River via the STP would be approximately the same as under the No Action Alternative. Following decommissioning, there would be no further discharges from the HFBR to the Peconic River.

4.5.5.2 Groundwater

After removal of radioactive fluids from the facility, the permanent shutdown of the HFBR would eliminate the potential for discharge of tritium to groundwater through process system leaks. It would also eliminate the potential for discharge of tritium to groundwater via Recharge Basin HO.

4.5.6 POTENTIAL MITIGATION MEASURES

Impacts to groundwater from a leak in the sewer lines under the HFBR could occur under all of the alternatives. Mitigation measures currently planned include further leak testing of the system to insure compliance with building and sanitary code requirements and, if required, necessary repairs (Ports 1998b). All liquid tritium discharges, from the secondary cooling system as well as the sanitary system, are directly influenced by the concentration of tritium in the primary system. Periodic changeouts (replacement of approximately 40 to 50 percent of the total primary system inventory) can be used to keep the tritium concentration in the primary system as low as reasonable (Ports 1998b).

4.6 GEOLOGY/SEISMICITY

4.6.1 NO ACTION ALTERNATIVE

No impacts to geologic or soil resources would occur during ground-disturbing construction activities as none are planned for this alternative.

A low seismic risk exists for the building and reactor structures, which were designed for horizontal accelerations of 0.1 g (BNL 1964). The maximum horizontal acceleration recorded in the area was between 0.007 g and 0.015 g (USGS 1998). No active earthquake-producing faults are known in the Long Island area (ERDA 1977). Section 2.3.4 of this DEIS discusses reinforcements planned for the control room housing radiological monitoring and control systems which were determined to be necessary after analysis of the effects of an earthquake producing ground accelerations of 0.2 g.

4.6.2 RESUME OPERATION ALTERNATIVE - 30 MW POWER LEVEL

Impacts to geologic or soil resources from this alternative would be the same as those discussed for the No Action Alternative.

Impacts as a result of seismic activity for this alternative would be the same as those discussed for the No Action Alternative.

4.6.3 RESUME OPERATION ALTERNATIVE - 60 MW POWER LEVEL

Impacts to geologic or soil resources from this alternative would be the same as those discussed for the No Action Alternative.

Impacts as a result of seismic activity for this alternative would be the same as those discussed for the No Action Alternative.

4.6.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

Impacts to geologic or soil resources from this alternative would be the same as those discussed for the No Action Alternative.

Impacts as a result of seismic activity for this alternative would be the same as those discussed for the No Action Alternative.

4.6.5 PERMANENT SHUTDOWN ALTERNATIVE

Impacts to geologic and soil resources could occur during, or as a result of, ground-disturbing D&D activities. The appropriate environmental reviews would be performed before D&D would be undertaken.

Impacts as a result of seismic activity for this alternative would be the same as those discussed for the No Action Alternative.

4.7 ECOLOGICAL RESOURCES

4.7.1 NO ACTION ALTERNATIVE

4.7.1.1 Terrestrial Resources

Under this alternative, no new construction would take place and the HFBR would remain in the shutdown condition. Therefore, there would be no impacts to the terrestrial resources of BNL.

4.7.1.2 Wetlands

No new construction would take place under this alternative and the HFBR would remain in the shutdown condition, therefore no impacts to wetlands on BNL would be expected.

4.7.1.3 Aquatic Resources

No new construction would take place under this alternative and the HFBR would remain in the shutdown condition, therefore, no impacts to aquatic resources on BNL would occur as a result of physical disturbance.

As discussed in Section 3.5.2.3, although the HFBR is not operational, wastewater from the facility is currently discharged to the Peconic River via the STP under a SPDES permit at a rate of approximately 0.15 MLD (40,000 GPD). The primary chemical of concern in this wastewater is tritium (see Section 3.5.2.3). Thus, impacts to aquatic resources could occur under the No Action Alternative as a result of this discharge. In 1997, the most recent year for which the *Site Environmental Report* has been prepared, the annual average tritium concentration in the STP Peconic River outfall was 1,366 pCi/l which is 7 percent of the SDWA standard (20,000 pCi/l) (BNL 1999).

No Federal or State tritium criteria exist for the protection of fish, wildlife or sensitive natural resources (IT 1998). However, DOE recommends a 1 rad/day exposure limit for aquatic biota (DOE 1993). According to the document entitled *A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment* (Killough and McKay 1976), both internal and external exposure doses to aquatic life can be calculated using computer models (EXREM III and BIORAD) based on a given radioactive concentration. Tables in that document provide pre-calculated exposure doses of 0.16 rad/day for external exposure and 0.52 rad/day for internal exposure based on a radioactive concentration of 1 μCi/ml (1,000,000,000 pCi/l) of tritium in water. Both of these calculated exposure doses are well below the DOE guideline level of 1 rad/day for aquatic biota.

The SDWA concentration limit of 20,000 pCi/l is over four orders of magnitude less than the 1,000,000,000 pCi/l concentration that produced the above calculated exposure doses. Therefore, since a concentration 50,000 times greater than the SDWA limit does not exceed the DOE exposure guidelines for aquatic biota, the SDWA level is considered to be fully protective of aquatic biota and is used as a conservative benchmark for evaluating impacts in the remainder of this section.

Since the estimated average annual concentration of tritium in the STP outfall to the Peconic River under the No Action Alternative is 1,366 pCi/l, 7 percent of the SDWA level, no exceedences of regulatory guidelines for tritium for the protection of aquatic life would be expected.

4.7.1.4 Threatened and Endangered Species

The tiger salamander is a New York State endangered species which has been found to breed and inhabit several wetlands onsite at BNL, but not near the HFBR. Other NYS species of special concern observed at BNL include the spotted salamander, spotted turtle, eastern hognose snake, and eastern bluebird. Other protected species observed as transients to BNL include the osprey and common nighthawk (DOE 1998).

The National Heritage Program identified no endangered, threatened or special concern species in the Peconic River in the vicinity of the STP. However further downstream, one NYS species of special concern which has been confirmed as an inhabitant is the banded sunfish. This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act (DOE 1998).

No new construction would take place under this alternative. Therefore, populations of Federal and State-listed endangered, threatened, or special concern species would not be impacted, either directly by displacement or indirectly by habitat alteration, as a result of construction activities.

4.7.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

4.7.2.1 Terrestrial Resources

Under this alternative, no new construction would take place. Therefore, there would be no impacts to the terrestrial resources of BNL due to physical disturbance from site development activities.

An increase in air emissions as a result of operation of the facility could potentially impact terrestrial resources via deposition or uptake from soils. As discussed in Section 4.4, the primary air quality issue under this alternative involves radioactive emissions. As noted in Section 4.11, the HFBR has operated at the 30 MW power level numerous times in the past. Data from the year 1995, as reported in the 1995 *Site Environmental Report* (BNL 1996a), was used to evaluate the 30 MW operations. In 1995, soil and vegetation were collected from offsite locations as part of the Soil and Vegetation Sampling Program, and analyzed for radioactive content. This program was a cooperative effort between BNL and SCDHS. Samples from local farms situated adjacent to BNL were collected (three soil samples, four vegetation samples). All radionuclides detected in these samples were of natural origin. No nuclides attributable to BNL's operations were detected (BNL 1996a). Based on this information, no appreciable impacts to terrestrial resources under the 30 MW Alternative would be expected.

4.7.2.2 Wetlands

No new construction would take place under this alternative, therefore no impacts to wetlands on BNL would occur as a result of physical disturbance.

The primary air quality issue during operation of the facility under this alternative involves radioactive emissions. As discussed in Section 4.7.2.1 above, no appreciable impacts to vegetation and soil due to radioactive emissions would be expected.

4.7.2.3 Aquatic Resources

No new construction would take place under this alternative, therefore no impacts to aquatic resources on BNL would occur as a result of physical disturbance.

Operation of the facility would result in a discharge of 0.27 MLD (71,000 GPD) of treated water from the STP to its permitted outfall on the Peconic River (Ports 1998a). As discussed in Section 4.5.2.1, under the 30 MW Alternative the annual average concentration of tritium at the outfall is expected to be up to approximately 3,000 pCi/l which is 15 percent of the SDWA concentration limit of 20,000 pCi/l, and used as a conservative benchmark for evaluating impacts to aquatic biota. As discussed in Section 4.7.1, this predicted concentration would be expected to result in a dose far below the DOE exposure guideline of 1 rad/day for aquatic biota. Therefore, no exceedences of regulatory guidelines for tritium for the protection of aquatic life in the Peconic River would be expected under this alternative.

Operation of the facility would also result in discharge of approximately 0.34 MLD (90,000 GPD) of cooling water to Recharge Basin HO (Ports 1998a), one of the aquatic communities described in Section 3.7.2.3. The primary chemical of concern in this discharge is tritium (see Section 3.5.2.3). The HFBR has operated at the 30 MW level in the past, and the 1995 *Site Environmental Report* which covered operations at this level reported that no radionuclides attributable to BNL operations were detected in the recharge basin in that year (BNL 1996a). Based on this information, the additional discharge to Recharge Basin HO from operation at 30 MW would not be expected to have appreciable impacts on aquatic resources.

4.7.2.4 Threatened and Endangered Species

The tiger salamander is a New York State endangered species which has been found to breed and inhabit several wetlands onsite at BNL, but not near the HFBR. Other NYS species of special concern observed at BNL include the spotted salamander, spotted turtle, eastern hognose snake, and eastern bluebird. Other protected species observed as transients to BNL include the osprey and common nighthawk (DOE 1998).

The National Heritage Program identified no endangered, threatened or special concern species in the Peconic River in the vicinity of the STP. However further downstream, one NYS species of special concern which has been confirmed as an inhabitant is the banded sunfish. This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act (DOE 1998).

No new construction would take place under this alternative. Therefore, populations of Federal and State-listed endangered, threatened, or special concern species would not be impacted, either directly by displacement or indirectly by habitat alteration, as a result of construction activities.

4.7.3 RESUME OPERATION ALTERNATIVE — 60 MW POWER LEVEL

4.7.3.1 Terrestrial Resources

Potential impacts to terrestrial resources from the 60 MW power level would be similar to those discussed for the 30 MW power level operating scenario. No construction impacts would be expected.

As discussed in Section 4.11, data from previous 60 MW operations (1988) can be used to represent this alternative. The BNL *Site Environmental Report for Calendar Year 1988* included the results of a Soil and Vegetation Sampling Program which was a cooperative effort between BNL and SCDHS (BNL 1989). Local farms situated around BNL were sampled semiannually. No nuclides attributable to BNL operations were detected in any of these samples. Based on this information, no appreciable impacts to terrestrial resources under the 60 MW Alternative would be expected.

4.7.3.2 Wetlands

Potential impacts to wetlands from the 60 MW power level would be similar to those discussed for the 30 MW power level operating scenario. No construction impacts would be expected.

As discussed in Section 4.7.3.1 above, no appreciable impacts to vegetation and soil due to radioactive emissions would be expected.

4.7.3.3 Aquatic Resources

Potential impacts to aquatic resources from the 60 MW power level would be similar to those under the 30 MW power level operating scenario. No construction impacts would be expected.

Discharges to the Peconic River from the STP would be approximately 0.33 MLD (86,000 GPD) (Ports 1998a). As discussed in Section 4.5.3.1, the annual average concentration of tritium in the STP outfall under the 60 MW Alternative is expected to be up to approximately 3,000 pCi/l, 15 percent of the SDWA concentration limit, which is used as a conservative benchmark for evaluating impacts to aquatic biota. As discussed in Section 4.7.1, this predicted concentration would be expected to result in a dose far below the DOE exposure guideline of 1 rad/day for aquatic biota. Therefore, no exceedences of regulatory guidelines for tritium for the protection of aquatic life in the Peconic River would be expected under this alternative.

Discharges to Recharge Basin HO under the 60 MW Alternative would be approximately 0.74 MLD (195,000 GPD) (Ports 1998a). In 1988, when the reactor operated at 60 MW, the effluent discharged to Recharge Basin HO contained only trace quantities of radioactivity. These concentrations were all small fractions of the SDWA concentration limit of 20,000 pCi/l for tritium (BNL 1989), which is used as a conservative benchmark for evaluating impacts to aquatic biota. As discussed in Section 4.7.1, the SDWA level is expected to result in a dose far below the DOE exposure guideline of 1 rad/day for aquatic biota. Therefore, no exceedences of regulatory guidelines for tritium for the protection of aquatic life in surface water due to discharges to Recharge Basin HO would be expected under this alternative.

4.7.3.4 Threatened and Endangered Species

The tiger salamander is a New York State endangered species which has been found to breed and inhabit several wetlands onsite at BNL, but not near the HFBR. Other NYS species of special concern observed at BNL include the spotted salamander, spotted turtle, eastern hognose snake, and eastern bluebird. Other protected species observed as transients to BNL include the osprey and common nighthawk (DOE 1998).

The National Heritage Program identified no endangered, threatened or special concern species in the Peconic River in the vicinity of the STP. However further downstream, one NYS species of special concern which has been confirmed as an inhabitant is the banded sunfish. This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act (DOE 1998).

No new construction would take place under this alternative. Therefore, populations of Federal and State-listed endangered, threatened, or special concern species would not be impacted, either directly by displacement or indirectly by habitat alteration, as a result of construction activities.

4.7.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

4.7.4.1 Terrestrial Resources

Under this alternative, no new construction would take place and there would be no impacts to the terrestrial resources of BNL due to physical disturbance from site development activities.

Operation of the facility could result in air quality impacts to terrestrial resources similar to those described under the 60 MW Alternative. As discussed in Section 4.7.3.1, no appreciable impact to terrestrial resources would be expected as a result of such air quality impacts.

4.7.4.2 Wetlands

No new construction would take place under this alternative, therefore no impacts to wetlands on the BNL site would occur as a result of physical disturbance.

Operation of the facility could result in air quality impacts similar to those described under the 60 MW Alternative. As discussed in Section 4.7.3.2, no appreciable impacts to vegetation and soil due to radioactive emissions would be expected.

4.7.4.3 Aquatic Resources

No new construction would take place under this alternative, therefore no impacts to aquatic resources on BNL would occur as a result of physical disturbance under this alternative.

Impacts during operation of the facility would include discharges to Recharge Basin HO and the Peconic River as described under the 60 MW Alternative. As discussed in Section 4.7.3.3, no exceedences of regulatory guidelines for tritium for the protection of aquatic biota would be expected as a result of these discharges under this alternative.

4.7.4.4 Threatened and Endangered Species

The tiger salamander is a New York State endangered species which has been found to breed and inhabit several wetlands onsite at BNL, but not near the HFBR. Other NYS species of special concern observed at BNL include the spotted salamander, spotted turtle, eastern hognose snake, and eastern bluebird. Other protected species observed as transients to BNL include the osprey and common nighthawk (DOE 1998).

The National Heritage Program identified no endangered, threatened or special concern species in the Peconic River in the vicinity of the STP. However further downstream, one NYS species of special concern which has been confirmed as an inhabitant is the banded sunfish. This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act (DOE 1998).

No new construction would take place under this alternative. Therefore, populations of Federal and State-listed endangered, threatened, or special concern species would not be impacted, either directly by displacement or indirectly by habitat alteration, as a result of construction activities.

4.7.5 PERMANENT SHUTDOWN ALTERNATIVE

Potential impacts of this alternative for the HFBR on ecological resources would be similar to those under the No Action Alternative since the HFBR would be placed in an industrially safe and radiologically secure state for eventual D&D.

4.7.5.1 Terrestrial Resources

No new construction would take place under this alternative, therefore there would be no impacts to the terrestrial resources of BNL.

4.7.5.2 Wetlands

No new construction would take place under this alternative, therefore no impacts to wetlands on BNL would be expected.

4.7.5.3 Aquatic Resources

No new construction would take place under this alternative, therefore no impacts to aquatic resources on BNL would occur as a result of physical disturbance under this alternative. Following decommissioning, there would be no further discharges from the HFBR to the Peconic River.

4.7.5.4 Threatened and Endangered Species

The tiger salamander is a New York State endangered species which has been found to breed and inhabit several wetlands onsite at BNL, but not near the HFBR. Other NYS species of special concern observed at BNL include the spotted salamander, spotted turtle, eastern hognose snake, and eastern bluebird. Other protected species observed as transients to BNL include the osprey and common nighthawk (DOE 1998).

The National Heritage Program identified no endangered, threatened or special concern species in the Peconic River in the vicinity of the STP. However further downstream, one NYS species of special concern which has been confirmed as an inhabitant is the banded sunfish. This species occurs in New York solely within the Peconic River system. That portion of the Peconic River which occurs on BNL property has been designated as "scenic" in accordance with New York State's Wild, Scenic, and Recreational River Act (DOE 1998).

No new construction would take place under this alternative. Therefore, populations of Federal and State-listed endangered, threatened, or special concern species would not be impacted, either directly by displacement or indirectly by habitat alteration, as a result of construction activities.

4.8 CULTURAL RESOURCES

The description of the Cultural Resources environment can be found in Section 3.8. During the preparation of this EIS, the State Historic Preservation Office (SHPO) was contacted. Based on their review of the alternatives being considered, no alternative would have an effect on any resources listed in or eligible for the NRHP. The SHPO response is in Appendix D. Moreover, no paleontological remains have been discovered to date at BNL.

4.8.1 NO ACTION ALTERNATIVE

This alternative does not present a potential impact to cultural resources because there are no known affected resources in the region.

4.8.2 RESUME OPERATION ALTERNATIVE - 30 MW POWER LEVEL

This alternative does not present a potential impact to cultural resources because there are no known affected resources in the region.

4.8.3 RESUME OPERATION ALTERNATIVE - 60 MW POWER LEVEL

This alternative does not present a potential impact to cultural resources because there are no known affected resources in the region.

4.8.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

This alternative does not present a potential impact to cultural resources because there are no known affected resources in the region.

4.8.5 PERMANENT SHUTDOWN ALTERNATIVE

This alternative does not present a potential impact to cultural resources because there are no known affected resources in the region.

4.9 SOCIOECONOMICS

4.9.1 NO ACTION ALTERNATIVE

Upon completion of the facility repairs and modifications, there would likely be a reduction of the existing workforce from approximately 120 employees to 69 employees. The net reduction of approximately 50 employees would have minor adverse impacts on the ROI. The reduced No Action Alternative workforce is used as a baseline for all other alternatives.

The 69 employees (that is, involved and noninvolved workers) associated with the No Action Alternative would have a total annual payroll (which includes employee salaries, benefits, administrative costs, etc.) of approximately $10.9 million. There would be a total of 237 jobs (69 direct and 168 indirect) in the ROI associated with the No Action Alternative. This represents approximately 0.02 percent of ROI employment. Total earnings in the ROI as a result of this alternative would be $21.5 million, approximately 0.02 percent of ROI earnings. Since any jobs generated would likely be filled by the existing ROI workforce, there would be no in-migration of population and therefore no impact to regional housing markets or public services.

4.9.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

This alternative would require 130 employees with a total annual payroll of approximately $19.2 million, which is an increase of 61 employees and $8.3 million compared to the No Action Alternative. Operating and maintenance costs would likely be paid out of BNL budgets, although such expenditures would require Congressional appropriations. (Section 512 of the Conference Report accompanying Public Law 105-62, the *Energy and Water Development Appropriations Act* of 1998 prohibited the use of funds for restarting the HFBR in fiscal 1998, and the *Energy and Water Development Appropriations Act* of 1999 [Public Law 105-245] prohibits the use of 1999 funds for restarting the HFBR.) A total of 209 additional jobs (61 direct and 148 indirect) would be generated as a result of this alternative. This increase in additional jobs represents an increase of approximately 0.02 percent of ROI employment. Total earnings in the ROI would increase by $16.4 million, which is an increase of approximately 0.02 percent of ROI earnings. Because any jobs generated would likely be filled by the existing ROI workforce, there would be no in-migration of population and therefore no impact to regional housing markets or public services.

In addition to the permanent workforce associated with the operation of the HFBR, there could be as many as 400 visiting scientists using the reactor each year for research. The average stay of each visiting scientist is approximately 7 to 10 days. While there could be some increased economic benefit to the ROI in the form of additional expenditures, these scientists would have little, if any, long-term impact on the ROI economy.

4.9.3 RESUME OPERATION ALTERNATIVE – 60 MW POWER LEVEL

The socioeconomic impacts from this alternative would be identical to the Resume Operations Alternative–30 MW Power Level. Worker requirements would be the same. No additional expenditures above those required for the 30 MW Alternative would be made.

4.9.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

The socioeconomic impacts from this alternative would be identical to the Resume Operations Alternative–30 MW Power Level. Worker requirements would be the same. No additional expenditures above those required for the 30 MW Alternative would be made. Some temporary employment and expenditures would be associated with enhancement activities.

However, these would be minor and have a very slight short-term impact on the ROI economy.

4.9.5 PERMANENT SHUTDOWN ALTERNATIVE

Under this alternative, the HFBR would be permanently shutdown for eventual D&D. There would still be a small workforce associated with the HFBR to prepare the reactor for eventual D&D. There would be approximately 93 employees temporarily associated with this alternative with an annual payroll of $13.4 million, which is an increase of 24 employees and $2.5 million compared to the No Action Alternative. A total of 82 additional jobs (24 direct and 58 indirect) would be generated as a result of this alternative. This increase in additional jobs represents an increase of approximately 0.01 percent of ROI employment. Total earnings in the ROI would increase by approximately $4.9 million, an increase of approximately 0.01 percent in ROI earnings. Because any jobs generated would likely be filled by the existing ROI workforce, there would be no in-migration of population and therefore no impact to regional housing markets or public services. In the long run, once decisions about the D&D needs of the HFBR have been made, the workforce would eventually become zero. This would have a slight adverse impact on the ROI economy.

4.10 TRANSPORTATION

4.10.1 NO ACTION ALTERNATIVE

4.10.1.1 Traffic

Under the No Action Alternative, there would be no impact on traffic. Traffic conditions would continue as they currently exist.

4.10.1.2 Transportation

All spent fuel elements from the HFBR have been transported offsite. Therefore, under the No Action Alternative, there would be no transport of spent fuel and thus no transportation impacts.

4.10.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER

4.10.2.1 Traffic

The number of BNL employees affiliated with operation of the HFBR under the 30 MW Alternative is estimated to be 130 (Ports 1998d). Approximately 400 scientists would be expected to visit BNL specifically to do research at the HFBR, staying an average of seven to ten days (Rorer 1998). It is anticipated that most scientific visitors would remain onsite during their visit, so their presence would have only a minor impact on the daily traffic flow. Therefore, implementation of the 30 MW Alternative would not have any appreciable impacts on traffic.

4.10.2.2 Transportation

Under the maximum number of operating cycles at 30 MW, the HFBR could generate up to 77 spent fuel elements in one year (Ports 1998d). In 1997, DOE reported that the number of spent fuel elements which can be transported offsite in a steel-encased, lead-shielded shipping cask is 42 (DOE 1997a). Therefore, if there was no long-term storage of spent fuel elements in the spent fuel pool, an average of two casks per year could be required to transport spent fuel elements offsite under this alternative. However, spent fuel elements are stored to allow for thermal cooling and then shipped in a single shipping campaign. At 30 MW, a shipping campaign would be expected approximately once every five years, using five shipping casks for a total shipment of 210 elements. As discussed in Section 3.10.2.2, periodically reactor vessel components and internal parts would also be replaced and shipped offsite in casks similar to the spent fuel element casks.

Based in part on the analysis of the SNF PEIS, DOE decided to manage spent nuclear fuel of the type associated with the HFBR at the SRS. Therefore, based on the assessment presented in the SNF PEIS, it is concluded that no major impacts should occur from the transport of spent fuel elements from the HFBR under the 30 MW Alternative.

4.10.3 RESUME OPERATION ALTERNATIVE – 60 MW POWER

4.10.3.1 Traffic

The number of personnel working on the HFBR at the 60 MW power level would be the same as for the 30 MW power level (130 BNL employees plus up to 400 visiting scientists per year). Therefore, as discussed Section 4.10.2.1, implementation of the 60 MW Alternative would not result in any appreciable impacts on traffic.

4.10.3.2 Transportation

Under the maximum number of operating cycles at 60 MW, the HFBR could generate as many as 158 spent fuel elements in one year (Ports 1998d). Since 42 spent fuel elements can be transported offsite in a steel-encased, lead-shielded shipping cask (DOE 1997a), an average of four casks would normally be required to transport spent fuel elements offsite per year. However, spent fuel elements are stored to allow for thermal cooldown and then shipped in a single shipping campaign using five casks for a total shipment of 210 elements. At 60 MW, a shipping campaign would be expected approximately once every three years. Based on the discussion presented in Section 4.10.2.2, no appreciable transportation impacts are anticipated under this alternative.

4.10.4 RESUME OPERATION AND ENHANCED FACILITY ALTERNATIVE

4.10.4.1 Traffic

The number of personnel working on an upgraded HFBR at the 30 MW or 60 MW power level would remain unchanged at approximately 130 BNL employees and up to 400 visiting scientists per year. Short-term traffic associated with any enhancement activities would likely add less than 100 vehicle round trips on any given day to the local traffic volume. This represents less than one half of one percent of local traffic along the William Floyd Parkway under current conditions (22,500 vehicles/day – see Section 3.10.2.1). Therefore, no appreciable impacts on traffic are expected under this alternative.

4.10.4.2 Transportation

The number of spent fuel elements generated over a course of one year with an upgraded HFBR at the 30 MW or 60 MW power level would be, at most, 77 or 158, respectively. Therefore, the potential impact discussion presented in Sections 4.10.2.2 and Section 4.10.3.2 would apply to this alternative as well. No appreciable potential transportation impacts are anticipated.

4.10.5 PERMANENT SHUTDOWN ALTERNATIVE

4.10.5.1 Traffic

If the Permanent Shutdown Alternative is selected, many of the 130 BNL personnel assigned to the HFBR would be reassigned to other research activities and facility maintenance needs. Therefore, there would be no appreciable impact on traffic due to these employees. However, a permanent shutdown would eventually result in D&D activities. Impacts due to additional vehicular traffic volume associated with D&D activities would be addressed in a separate NEPA review of D&D activities.

4.10.5.2 Transportation

If the HFBR is scheduled for permanent shutdown, reactor vessel internal components would require removal and transport offsite in similar casks as described in Section 3.10.2.2. Those activities would be addressed in an appropriate NEPA D&D review.

4.11 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

This section describes the public and occupational health and safety impacts for each of the proposed alternatives for the HFBR. The impacts discussed in this section consider both radiological and chemical impacts and are presented for both offsite and onsite areas, as appropriate. The onsite area is defined as the area within the confines of BNL, while the offsite is considered to be an area of 80 km (50 mi) radius centered on the HFBR, but beyond BNL's boundaries.

Health effects for the HFBR operations are determined by identifying the types and quantities of materials to which a person could be exposed, estimating exposures, and calculating the effects resulting from the exposures. The impacts on human health for workers and the public during normal operations and postulated accidents for each of the alternatives are assessed. For more information on how risk estimates are calculated, the reader should refer to Appendix C.

Experiences from past and current operations that are similar to potential future operations are used to estimate the radiological health impact to the public and workers. The modeling used is primarily that which was used in the reference documents to estimate the type and amount of material released and the associated doses. In particular, BNL *Site Environmental Reports* for the years 1988, 1995, and 1997 were chosen as the source documents since these were the most recent years that the reactor was operated at 60 MW and 30 MW and was shutdown. These years are considered representative because they provide the best available representation of the expected HFBR configuration and operation practices for the various alternatives. Although these years were chosen, the impacts associated with routine releases are not solely influenced by reactor power level. In fact, the primary factors are the tritium concentration in the primary coolant and the occurrences of reactor vessel depressurization and maintenance operations. The doses calculated by the modeling are converted to health effects using appropriate health risk estimators. More detailed information on the modeling used and converting doses to health effects is provided in Appendix C.

The relative consequences of postulated accidents in the evaluation of each alternative are assessed. The accident analysis involves considerable detail, drawing from formal existing *Probabilistic Risk Assessments* (PRAs) (BNL 1990a, BNL 1990b, BNL 1993, BNL 1994) and safety analyses (BNL 1998f). The accident analysis discusses "design basis accidents" (to say that an accident is "within the design basis" is to say that it has been allowed for in the design of the facility or that the design is capable of dealing with the accident) and "beyond design basis accidents" (a "beyond design basis accident" is an accident of the same type as a design basis accident, but complicated by factors that exceed the design capabilities of dealing with the accident), and a representative spectrum of possible operational accidents. Additional information on the accident analysis and associated consequence modeling is provided in Appendix C, Section C.5.

The *U.S. Nuclear Regulatory Commission Safety Assessment of the High Flux Beam Reactor at the Brookhaven National Laboratory* (NRC 1999) "identified no safety-significant issues, although several apparent instances of noncompliance with DOE and BNL requirements were noted." The report concludes that "the safety programs at the HFBR were found to provide adequate protection of the health and safety of the public, the workers, and the environment."

4.11.1 NO ACTION ALTERNATIVE

This section discusses the impacts of the No Action Alternative. These impacts serve as the baseline against which the impacts of the other alternatives are compared. The year chosen to represent the HFBR in a shutdown condition is 1997 because it is the latest year for which a full year of data is available for this condition. Thus

HFBR data for 1997 are used in analyzing impacts of the No Action Alternative.

4.11.1.1 Normal Operations

Radiological Impacts: Since the reactor would have no fuel in the core, the radiological impacts for the No Action Alternative would be attributable to activities other than operation of the reactor. Radioactive releases from the reactor resulting from normal reactor operation would no longer be possible. However, since the modification activities that are part of the No Action Alternative would be necessary to conform with Suffolk County Sanitary Code, Articles 7 and 12, and since the majority of the exposures occur during maintenance activities, some radiological impacts may be experienced.

During 1997, the HFBR experienced the following airborne releases (BNL 1999):

- 27 Ci of tritium (H^3)
- 1.9×10^{-8} Ci of Cs^{137}
- 5.7×10^{-8} Ci of Co^{60}
- 6.5×10^{-8} Ci of Fe^{52}
- 8.8×10^{-8} Ci of Rb^{84}

Based on these airborne releases and using the CAP88-PC model, the annual dose to the MEI was calculated to be 8.0×10^{-5} (0.00008) mrem. The annual offsite population dose attributable to HFBR operations was calculated to be 0.0098 person-rem and the average annual dose to an offsite individual was determined to be 1.9×10^{-6} (0.0000019) mrem. The above dose data and associated latent cancer fatalities (LCF) are summarized in Table 4.11-1, which depicts impacts to the public for this alternative. As a means of comparison, the same offsite population would receive a population dose due to background radiation sources of 1.8×10^{6} (1,800,000) person-rem, which corresponds to about 900 potential LCFs.

Table 4.11-2 depicts annual radiological impacts to the involved workforce for this alternative. Based on 1997 worker dose data and a projected involved workforce of 49 workers for this alternative, the average involved worker would receive an annual dose of 98 mrem, the total involved worker annual dose would be 4.8 person-rem, and the maximally exposed

Table 4.11-1. Annual Radiological Impacts to the Public Attributable to the HFBR for the No Action Alternative

Receptor	Impacts
Individual	
Average dose (mrem/yr)	1.9×10^{-6}
Probability of latent cancer fatalities	9.7×10^{-13}
MEI	
Dose (mrem/yr)	8.0×10^{-5}
Probability of latent cancer fatalities	4.0×10^{-11}
General Population (EDE)	
Population dose (person-rem/yr)	0.0098
Latent cancer fatalities	4.9×10^{-6}

Notes:
1. The average dose and population dose were calculated by the CAP88-PC model (EPA 1992), using a population of 5,053,187. The population input file for the CAP88-PC model was derived from customer records of LILCO (now LIPA). Not that, because of differences in population input file formats for the CAP88-PS model and the MACCS code (the computer code used to calculate accident radiological consequences (see SNL 1990a, SNL 1990b, SNL 1990c), a different offsite population (5,356,270) was used to calculate offsite accident doses. This population and associated offsite population distribution were calculated using SECPOP90 (Humphreys 1997). SECPOP90 is a computer program that provides population and economic data estimates for any location in the U.S. with the results available in MACCS site file format.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for the public of 0.0005 latent cancer fatalities per person-rem.

Source: NAS 1990, BNL 1999.

Table 4.11-2. Annual Radiological Impacts to the Workforce Attributable to the HFBR for the No Action Alternative

Receptor	Impacts
Involved Workforce	
Collective dose (person-rem)	4.8
Latent cancer fatalities	0.0019
Average dose (mrem)	98
Maximally exposed involved worker (mrem)	513
Noninvolved Workforce	
Maximally exposed noninvolved worker (mrem)	$2.4x10^{-4}$
Probability of latent cancer fatality	$9.6x10^{-11}$

Notes:
1. For involved workers, the average dose and collective dose were calculated using an involved worker population of 49.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for workers of 0.0004 latent cancer fatalities per person-rem.
Source: NAS 1990, Reciniello 1998.

involved worker would receive an annual dose of 513 mrem. The maximally exposed noninvolved worker would receive an annual dose of $2.4x10^{-4}$ mrem.

Based on the above dose values and the associated estimated latent cancer fatalities, the radiological impacts to the public and workers from the normal operations associated with the No Action Alternative are expected to be minimal. Additionally, the doses to the public would be within the limits of DOE Order 5480.5 and 40 CFR Part 61. Worker doses would be within the limits of 10 CFR Part 835.

Hazardous Chemical Impacts: For this alternative, the HFBR facility would undergo the five modifications discussed in Section 2.3. None of these modifications would be expected to introduce considerable quantities of chemicals into the facility. Thus, based on the discussion in Section 3.11.2.2 that the hazards associated with the chemicals that may be stored or used at the HFBR would have only minor impacts, it is expected that there would be only small impacts from hazardous chemicals for the No Action Alternative.

4.11.1.2 Facility Accidents

Under the No Action Alternative, the facility would continue to have no nuclear fuel and therefore could not have an accident involving fuel damage. The remaining radiological hazards are the D_2O coolant (which contains some tritium), such experimental quantities of radionuclides as may remain in the facility, and the activated or contaminated portions of the facility itself. Postulated accidents involving these items are not expected to lead to significant airborne releases external to the confinement building. A fire inside the confinement building could drive contamination into the confinement building atmosphere, but relatively little would escape through the high-efficiency particulate air (HEPA) filters. A D_2O spill can be postulated, but involved workers would receive doses only on the order of 1.0 mrem, so this accident was not evaluated further. The event would have extremely small consequences to the non-involved worker and the public.

4.11.2 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

4.11.2.1 Normal Operations

Radiological Impacts: The HFBR operated at the 30 MW power level from 1991 to 1996. Emission and dose data from the year 1995 are used in analyzing impacts from operation of the HFBR at 30 MW. The year 1995 was chosen because it was the most recent year for which the HFBR operated at 30 MW for the entire year.

The major radionuclides released by the HFBR during 1995 were (BNL 1996a):

- 97.6 Ci of H^{3}
- $9.8x10^{-6}$ Ci of Ba^{128}
- $9.8x10^{-7}$ Ci of Be^{7}
- $2.3x10^{-6}$ Ci of Br^{77}
- $2.1x10^{-3}$ Ci of Br^{82}
- $1.8x10^{-7}$ Ci of Co^{60}
- $3.0x10^{-8}$ Ci of Cs^{137}
- $4.8x10^{-6}$ Ci of I^{126}
- $1.4x10^{-6}$ Ci of I^{131}
- $6.5x10^{-5}$ Ci of K^{40}
- $1.5x10^{-6}$ Ci of Mn^{56}
- $8.3x10^{-6}$ Ci of Xe^{133}
- $5.6x10^{-7}$ Ci of Xe^{133m}
- $5.2x10^{-6}$ Ci of Xe^{135}

Based on these airborne releases, the annual dose to the MEI was calculated to be $3.0x10^{-4}$ (0.0003) mrem using the CAP88-PC dose model. The annual offsite population dose attributable to HFBR operations was calculated to be 0.035 person-rem and the average annual dose to an offsite individual was determined to be $6.9x10^{-6}$ (0.0000069) mrem. The above dose data and associated latent cancer fatalities are summarized in Table 4.11-3, which depicts impacts to the public for this alternative. As a means of comparison, the same offsite population would receive a population dose due to background radiation sources of $1.8x10^{6}$ (1,800,000) person-rem, which corresponds to about 900 latent cancer fatalities.

Table 4.11-3. Annual Radiological Impacts to the Public Attributable to the HFBR for the 30 MW Alternative

Receptor	Impacts
Individual	
Average dose (mrem/yr)	$6.9x10^{-6}$
Probability of latent cancer fatalities	$3.4x10^{-12}$
MEI	
Dose (mrem/yr)	$3.0x10^{-4}$
Probability of latent cancer fatalities	$1.5x10^{-10}$
General Population (EDE)	
Population dose (person-rem/yr)	0.035
Latent cancer fatalities	$1.7x10^{-5}$

Notes:
1. The average dose and population dose were calculated by the CAP88-PC model (EPA 1992), using a population of 5,053,187. The population input file for the CAP88-PC model was derived from customer records of LILCO (now LIPA). Not that, because of differences in population input file formats for the CAP88-PS model and the MACCS code (the computer code used to calculate accident radiological consequences (see SNL 1990a, SNL 1990b, SNL 1990c), a different offsite population (5,356,270) was used to calculate offsite accident doses. This population and associated offsite population distribution were calculated using SECPOP90 (Humphreys 1997). SECPOP90 is a computer program that provides population and economic data estimates for any location in the U.S. with the results available in MACCS site file format.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for the public of 0.0005 latent cancer fatalities per person-rem.

Source: NAS 1990, BNL 1996a, Ports 1998f.

Table 4.11-4. Annual Radiological Impacts to the Workforce Attributable to the HFBR for the 30 MW Alternative

Receptor	Impacts
Involved Workforce	
Collective dose (person-rem)	13.8
Latent cancer fatalities	0.0055
Average dose (mrem)	133
Maximally exposed involved worker (mrem)	634
Noninvolved Workforce	
Maximally exposed noninvolved worker (mrem)	9.0×10^{-4}
Probability of latent cancer fatality	3.6×10^{-10}

Notes:
1. For involved workers, the average dose and collective dose were calculated using an involved worker population of 104.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for workers of 0.0004 latent cancer fatalities per person-rem.
Source: NAS 1990, Reciniello 1998.

Table 4.11-4 depicts annual radiological impacts to the involved workforce for this alternative. Based on 1995 worker dose data and a projected involved workforce of 104 workers for this alternative, the average involved worker would receive an annual dose of 133 mrem, the total involved worker annual dose would be 13.8 person-rem, and the maximally exposed involved worker would receive a dose of 634 mrem. The maximally noninvolved worker would receive an annual dose of 9.0×10^{-4} (0.0009) mrem.

Based on the above radiological impacts to the public and workers, resuming operation of the HFBR at a power level of 30 MW would have minimal impact on the health and safety of the public and workers from normal operations. Resuming operations at a power level of 30 MW would result in small increases in the annual doses to the MEI, the population, and the involved worker (0.00022 mrem, 0.025 person-rem, and 35 mrem, respectively) in comparison to the No Action Alternative. These dose increases would result in very small increases in the probability of a latent cancer fatality (the population would be expected to have an additional 0.00001 latent cancer fatalities and the workers would be expected to have an additional 0.001 latent cancer fatalities). Additionally, the doses to the public would be within the limits of DOE Order 5480.5 and 40 CFR Part 61. Worker doses would be within the limits of 10 CFR Part 835.

Hazardous Chemical Impacts: The same chemicals currently stored at the HFBR would remain at the facility for 30 MW operation. It has been shown in Section 3.11.2.2 that the hazards associated with these chemicals have minor impacts. It is therefore reasonable to assume that the chemicals have minimal safety impacts.

4.11.2.2 Facility Accidents

Representative accident sequences for this alternative are discussed in Appendix C. The impacts of these postulated accident sequences are summarized in Table 4.11-5. This table includes both credible accidents at 30 MW operation (large loss of coolant accident [LOCA] and fuel handling accident [FHA]) (a “credible” accident is an accident which has a 1 in 1,000,000 or greater chance of occurring per year, which is the same as a frequency greater than 10^{-6} per year) and, for comparison, an incredible accident (severe wind/tornado accident [SWT]) (an “incredible” accident is an accident which has less than a 1 in 1,000,000 chance of occurring each year, which is the same as a frequency of less than 10^{-6} per year).

Table 4.11-5 indicates that the consequences of the incredible SWT accident (81 potential LCFs to the public per accident [and 61 rem to the MEI per accident]) are worse than those of the credible accidents, although the "risk" (the possible frequency multiplied by the possible consequences) posed by this accident would be relatively minor ($6.4x10^{-5}$, or 0.000064, potential LCFs to the public per year [and $4.7x10^{-8}$, or a 0.000000047 of a LCF risk to the MEI]). The consequences and risks of the other scenarios are all less than the consequences and risk of the SWT accident. For the credible accidents at 30 MW operation (LOCA and FHA), the consequences are shown to be extremely small (less than 0.1 potential LCFs to the public per accident).

As explained in Appendix C, the accidents shown in Table 4.11-5 were chosen for comparison purposes. The accidents analyzed do not place an upper limit on the total risk, but they do show how key accident sequences vary across alternatives. Several of the accident sequences analyzed in the PRA were reanalyzed to address relevant studies performed subsequent to the issuance of the PRA, conservatisms in the original analysis, and facility enhancements.

Of the potential accident sequences leading to major core damage in the PRA, most would lead to consequences generally comparable to those that would be initiated by loss of offsite power (LOOP). In the loss of offsite power accident, a number of other failures are assumed to occur after LOOP, leading to a slow boiloff of coolant inventory followed by release of radionuclides from the core to the atmosphere of the confinement building. Some portion of this material could then escape through the HEPA filters to the environment through the stack. Many of the other potential "major" core damage accidents follow this general evolution with variations in timing.

The exception shown here is the SWT event. In the postulated SWT event, a severe wind would occur, causing not only LOOP, but also physical damage to the facility as a result of projectile impact (that is, a heavy object would be propelled by the force of extreme winds into the facility). It is physically possible for this to damage systems that could have been used to supply coolant, and is something like the LOOP accident as far as the core itself is concerned. However, in this event, the projectile would also cause a breach of confinement. Therefore, more radionuclides would escape than was the case for the LOOP-initiated accident. The plume would be closer to the ground, so the consequences would be worse than those of the LOOP-initiated accident.

The postulated large LOCA shown on this table would have no radiological consequences if it occurred at 30 MW; it is shown here for comparison with 60 MW, a power level at which the same event would have minor (but not zero) radiological consequences.

Table 4.11-5. 30 MW Operation Alternative Accident Impacts at the HFBR

	Onsite Noninvolved Worker Population		Maximally Exposed Offsite Individual		Population to 80 km		
Accident Description	**Population Dose Per Accident[d] (person-rem)**	**Number of Latent Cancer Fatalities Per Accident**	**Dose Per Accident (rem)**	**Probability of Latent Cancer Fatality**	**Population Dose Per Accident[e] (person-rem)**	**Number of Latent Cancer Fatalities Per Accident**	**Accident Frequency (per year)**
LOOP[a]	288	0.12	0.64	$3x10^{-4}$	8,400	4.2	$8.6x10^{-8}$ [f]
Large LOCA[b]	None [b]	None [b]	None [b]	None [b]	None [b]	None [b]	$6.5\ x10^{-5}$
SWT[c]	2,900	1.1	61	$6x10^{-2}$	160,000	81	$7.9x10^{-7}$ [f]
FHA	4	0.0016	0.0077	$4x10^{-6}$	59	0.03	$2.6x10^{-5}$

[a] Normal cooling function not available, core water inventory not replenished; core damage occurs. Ex-confinement release is somewhat filtered.

[b] Event postulated is a large break (greater than 13 in) successfully cooled at 30 MW with no core damage. Event is postulated for comparison with 60 MW, at which minor core damage occurs for a break of this size.

[c] Severe wind/tornado causes loss of offsite power, breaches confinement with projectile and also eliminates then-existing coolant makeup. Ex-confinement release not filtered because confinement is breached.

[d] Based on a total non-involved worker population of 2,686.

[e] Based on a total offsite population of 5,356,270. This population and the associated population distribution were calculated using SECPOP90 (Humphreys 1997). SECPOP90 is a computer program that provides population and economic data estimates for any location in the U.S. with the results available in MACCS site file format. MACCS is the code used to calculate accident radiological consequences (SNL 1990a, SNL 1990b, SNL 1990c). Note that, because of the differences in population input files for the MACCS code and the CAP88-PC model (the code used to calculate radiological consequences from normal operations, see EPA 1992,), a different offsite population (5,053,187) was used to calculate offsite doses from normal operations. The population input file for the CAP88-PC model was derived from customer records of LILCO (now LIPA).

[f] The LOOP and SWT accident frequencies reflect not only the frequency of initiating events, which would be the same at both power levels, but also subsequent failures, whose probabilities differ at different power levels because different times are available for actions to be taken. See Sections C.5.1.1.2.2 and C.5.1.1.2.4, respectively.

Notes:
1. The frequency of the spent fuel element accident is obtained by scaling the PRA result for 60 MW by the relative number of fuel elements handled at 30 MW.
2. The consequence estimates presented here for LOOP, Large LOCA, SWT, and FHA scenarios are based on calculations discussed in C.5.1.1.3.
3. The frequency of breaks greater than 13 inches is estimated based on arguments given in BNL 1990, BNL 1990b.
4. A D_2O release accident was postulated but was not evaluated in detail, and is not shown, because the involved worker would receive approximately 1 mrem from this accident, and noninvolved workers and the public would receive much less.
5. An Experimental Facility Accident comparable to the TRISTAN fire was postulated but was not evaluated in detail because its consequences were negligible.

Source: BNL 1990a, BNL 1990b, BNL 1993, BNL 1998f, Schmidt 1998, Wagage 1999, Palmrose 1999.

4.11.3 RESUME OPERATION ALTERNATIVE - 60 MW POWER LEVEL

4.11.3.1 Normal Operations

Radiological Impacts: Emission and dose data from 1988 are used in analyzing impacts from operation of the HFBR at 60 MW. The year 1988 was chosen as it represents the most recent year for which the HFBR operated at 60 MW.

The major radionuclides released from the HFBR during 1988 were (BNL 1989):

- 189 Ci of H^3
- $2.5x10^{-3}$ Ci of Br^{82}
- $2.6x10^{-4}$ Ci of I^{133}
- $5.7x10^{-5}$ Ci of I^{131}

Based on these airborne releases, the annual dose to the MEI was calculated to be $5.6x10^{-4}$ (0.00056) mrem using the CAP88-PC dose model. The annual offsite population dose attributable to HFBR operations was calculated to be 0.069 person-rem and the average annual dose to an offsite individual was determined to be $1.4x10^{-5}$ (0.000014) mrem. The above dose data and associated latent cancer fatalities are summarized in Table 4.11-6, which depicts impacts to the public for this alternative. As a means of comparison, the same offsite population would receive a population dose due to background radiation sources of $1.8x10^{6}$ person-rem, which corresponds to about 900 latent cancer fatalities.

Table 4.11-7 depicts annual radiological impacts to the involved workforce for this alternative. Based on 1988 worker dose data and a projected involved workforce of 104 workers for this alternative, the average involved worker would receive an annual dose of 203 mrem, the total involved worker annual dose would be 21.1 person-rem, and the maximally exposed involved worker would receive a dose of 870 mrem. The maximally noninvolved worker would receive an annual dose of $1.7x10^{-3}$ mrem.

Table 4.11-6. Annual Radiological Impacts to the Public Attributable to the HFBR for the 60 MW Alternative

Receptor	Impacts
Individual	
Average dose (mrem/yr)	$1.4x10^{-5}$
Probability of latent cancer fatalities	$6.8x10^{-12}$
MEI	
Dose (mrem/yr)	$5.6x10^{-4}$
Probability of latent cancer fatalities	$2.8x10^{-10}$
General Population (EDE)	
Population dose (person-rem/yr)	0.069
Latent cancer fatalities	$3.4x10^{-5}$

Notes:
1. The average dose and population dose were calculated by the CAP88-PC model (EPA 1992), using a population of 5,053,187. The population input file for the CAP88-PC model was derived from customer records of LILCO (now LIPA). Not that, because of differences in population input file formats for the CAP88-PS model and the MACCS code (the computer code used to calculate accident radiological consequences (see SNL 1990a, SNL 1990b, SNL 1990c), a different offsite population (5,356,270) was used to calculate offsite accident doses. This population and associated offsite population distribution were calculated using SECPOP90 (Humphreys 1997). SECPOP90 is a computer program that provides population and economic data estimates for any location in the U.S. with the results available in MACCS site file format.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for the public of 0.0005 latent cancer fatalities per person-rem.
Source: BNL 1989, NAS 1990, Ports 1998e.

Table 4.11-7. Annual Radiological Impacts to the Workforce Attributable to the HFBR for the 60 MW Alternative

Receptor	Impacts
Involved Workforce	
Collective dose (person-rem)	21.1
Latent cancer fatalities	0.0084
Average dose (mrem)	203
Maximally exposed involved worker (mrem)	870
Noninvolved Workforce	
Maximally exposed noninvolved worker (mrem)	1.7×10^{-3}
Probability of latent cancer fatality	6.8×10^{-10}

Notes:
1. For involved workers, the average dose and collective dose were calculated using an involved worker population of 104.
2. Latent cancer fatalities were calculated by using the dose-to-risk conversion factor for workers of 0.0004 latent cancer fatalities per person-rem.
Source: NAS 1990, Reciniello 1998.

Based on the above radiological impacts to the public and worker, operating the HFBR at a power level of 60 MW would have minimal impact on the health and safety of the public and workers from normal operations. Operating at a power level of 60 MW would result in increases in the annual doses to the MEI, the population, and the involved worker (0.00048 mrem, 0.059 person-rem, and 105 mrem) in comparison to the No Action Alternative. These dose increases would result in very small increases in the probability of a latent cancer fatality (the population would be expected to have an additional 0.00003 latent cancer fatalities and the workers would be expected to have an additional 0.004 latent cancer fatalities). Additionally, the doses to the public would be within the limits of DOE Order 5480.5 and 40 CFR Part 61. Worker doses would be within the limits of 10 CFR Part 835.

Hazardous Chemical Impacts: The chemical impacts for this alternative are the same as those for all the other alternatives when the reactor is operating. The amounts of chemicals stored at the facility are independent of the level of reactor power. The chemical impacts from this alternative are minimal.

4.11.3.2 Facility Accidents

Representative accident sequences for this alternative are discussed in Appendix C. The impacts of these accident sequences are summarized in Table 4.11-8. This table includes both credible accidents at 60 MW operation (large [LOCA and FHA) (a “credible” accident is an accident which has a 1 in 1,000,000 or greater chance of occurring per year, which is the same as a frequency greater than 10^{-6} per year) and, for comparison, an incredible accident (SWT) (an “incredible” accident is an accident which has less than a 1 in 1,000,000 chance of occurring each year, which is the same as a frequency of less than 10^{-6} per year).

Table 4.11-8 indicates that the consequences of the potential SWT accident (115 potential LCFs to the public per accident [and 110 rem to the MEI per accident]) are worse than those of other accidents, although the “risk” (the possible frequency multiplied by the possible consequences) posed by this accident would be relatively minor (1×10^{-4}, or 0.0001 potential LCFs to the public per year [and 9.6×10^{-8}, or a 0.000000096 probability of a LCF to the MEI per year]). The consequences and risks of the other scenarios are all less than the consequences and risk of the SWT accident. For the credible accidents at 60 MW (large LOCA and FHA), the consequences are shown to be extremely small (less than 0.1 potential LCFs to the public per accident.)

As explained in Appendix C, the possible accidents in Table 4.11-8 were chosen for comparison purposes. The accidents analyzed do not place an upper limit on the total risk, but they do show how key accident sequences vary across alternatives. Several of the accident sequences analyzed in the PRA were reanalyzed to address relevant studies performed subsequent to the issuance of the PRA, conservatisms in the original analysis, and facility enhancements.

Of the possible accident sequences leading to major core damage in the PRA, most would lead to consequences generally comparable to those initiated by LOOP. In the LOOP accident, a number of other failures are assumed to occur after loss of offsite power, leading to a slow boiloff of coolant inventory followed by release of radionuclides from the core to the atmosphere in the confinement building. Some portion of this material would then escape through the HEPA filters to the environment through the stack. Many of the other potential "major" core damage accidents follow this general evolution with variations in timing.

The exception shown here is the SWT event. In the postulated SWT event, a severe wind would occur, causing not only LOOP, but also physical damage to the facility as a result of projectile impact (that is, a heavy object would be propelled by the force of extreme winds into the facility). It is physically possible for this to damage systems that could have been used to supply coolant, and is something like the LOOP accident as far as the core itself is concerned. However, in this event, the projectile would also cause a breach of confinement. Therefore, more radionuclides would escape than was the case for the LOOP-initiated accident. The plume would be closer to the ground, so the consequences would be worse than those of the LOOP-initiated accident.

In comparing the potential 60 MW accident consequences to the potential 30 MW accident consequences, the following observations are made.

The offsite consequences of the LOOP and SWT accidents for 60 MW operation would be about 50 percent greater than for 30 MW operation. The variation of the consequences of the LOOP-initiated sequence and the SWT sequence with power level is a function of radionuclide inventory and accident timing.

The consequences of the FHA would vary less between 30 MW and 60 MW than might have been expected. This is a consequence of operational practices, which are adjusted according to power level to limit the consequences of this event to a consistent (low) level of severity. Specifically, handling of fuel is delayed longer after shutdown if the reactor has been operating at higher power, so that if an accident does occur, it is less severe as a result of the delay.

The large LOCA shown on this table has no radiological consequences if it occurs at 30 MW. The consequences at 60 MW would be a result of minor fuel damage followed by successful core cooling. The damage would occur because a break of the large size postulated in this event causes forced cooling to be lost, an event that would cause damage at this power level. Workers involved in managing this accident can receive doses on the order of 2.0 rem (refer to Appendix C).

The consequences to the noninvolved worker would vary in a counterintuitive way for the LOOP accident between 30 and 60 MW. This is because dose consequences would depend not only on the release itself, but also on how relocation of noninvolved workers who remain onsite after the accident is assumed to be implemented.

Note that 97 percent of the noninvolved workers are assumed to evacuate offsite following the LOOP accident at both 30 MW and 60 MW, and that these evacuated noninvolved workers receive minimal doses in comparison to the noninvolved workers who remain onsite. Onsite relocation is assumed to occur based on exceeding a projected dose rate limit (Wagage 1999). For the LOOP accident, because the accident dose rate is greater for 60 MW than at 30 MW operations, more noninvolved workers would be relocated at 60 MW than at 30 MW. For this accident, the reduced doses received by the extra noninvolved workers that relocate at 60 MW more than offset the increased doses received by the non-relocated, noninvolved workers at 60 MW. The net result is that the noninvolved worker population for 30 MW operation is calculated to receive a population dose per accident that is two person-rem (less than one percent) greater than the population dose per accident for 60 MW operation.

Doses to experimenters and other facility workers from design basis accidents (other than facility operators who are responding to the emergency) would be minimal. Doses to experimenters and other facility workers from beyond design basis accidents have not been systematically assessed. Most of the postulated accidents leading to core damage would proceed slowly enough that experimenters and other facility workers would leave the facility before dose rates could become significant. one possible exception to this is the postulated LOCA large enough to lead to minor core damage at 60 MW but not at 30 MW. (This LOCA has a frequency conservatively estimated at $6x10^{-5}$ per year.) Because of the minor core damage, doses to operators responding to this event at 60 MW were estimated to be 2.6 rem (see BNL 1993 and Section C.5.1.1.2.1). This dose, while well above doses from normal operations, would not itself exceed annual occupational dose limits. The released coolant itself would pose a separate (but lesser) hazard. Pending a systematic assessment of consequences to experimenters and other facility workers, this 2.6 rem dose is taken to bound the consequences to experimenters and other facility workers from the large LOCA at 60 MW. The other accidents discussed here would not exhibit a significant difference in doses to experimenters and other facility workers at 30 MW and 60 MW.

As explained in Appendix C, these accidents have been chosen for comparison purposes, not to place an upper limit on the total risk but to show how key accident sequences vary across alternatives. Of the accident sequences leading to major core damage in the PRA, most led to consequences generally comparable to those of the large LOCA and LOOP sequences tabulated here; the exception is the severe tornado event tabulated here. Several of the accident sequences analyzed in the PRA were reanalyzed, to address relevant studies performed subsequent to the issuance of the PRA, conservatisms in the original analysis, and facility enhancements.

Table 4.11-8. 60 MW Operation Alternative Accident Impacts at HFBR

	Onsite Noninvolved Worker Population		Maximally Exposed Offsite Individual		Population to 80 km		
Accident Description	**Population Dose Per Accident[d] (person-rem)**	**Number of Latent Cancer Fatalities Per Accident**	**Dose Per Accident (rem)**	**Probability of Latent Cancer Fatality**	**Population Dose Per Accident[e] (person-rem)**	**Number of Latent Cancer Fatalities Per Accident**	**Accident Frequency (per year)**
LOOP[a]	286	0.11	1.1	$6x10^{-4}$	12,000	6.2	$2.6x10^{-7}$ [f]
Large LOCA[b]	11	0.0046	0.022	$1x10^{-5}$	149	0.075	$6.5\ x10^{-5}$
SWT[c]	3,300	1.3	110	0.11	230,000	115	$8.7x10^{-7}$ [f]
FHA	4.6	0.0018	0.0082	$4x10^{-6}$	68	0.03	$6.0x10^{-5}$

[a] Exclusive of anticipated transient without scram (ATWS). Normal cooling function not available, core water inventory not replenished; core damage occurs. Ex-confinement release is somewhat filtered.

[b] Event postulated is a large break (greater than 13 in) with minor core damage, stabilized thereafter by the Environmental Facilities Cooler (EFC).

[c] Severe wind/tornado causes loss of offsite power, breaches confinement with projectile and also eliminates then-existing coolant makeup. Ex-confinement release not filtered because confinement is breached.

[d] Based on a total non-involved worker population of 2,686.

[e] Based on a total offsite population of 5,356,270. This population and the associated population distribution were calculated using SECPOP90 (Humphreys 1997). SECPOP90 is a computer program that provides population and economic data estimates for any location in the U.S. with the results available in MACCS site file format. MACCS is the code used to calculate accident radiological consequences (SNL 1990a, SNL 1990b, SNL 1990c). Note that, because of the differences in population input files for the MACCS code and the CAP88-PC model (the code used to calculate radiological consequences from normal operations, see EPA 1992,), a different offsite population (5,053,187) was used to calculate offsite doses from normal operations. The population input file for the CAP88-PC model was derived from customer records of LILCO (now LIPA).

[f] The LOOP and SWT accident frequencies reflect not only the frequency of initiating events, which would be the same at both power levels, but also subsequent failures, whose probabilities differ at different power levels because different times are available for actions to be taken. See Sections C.5.1.1.2.2 and C.5.1.1.2.4, respectively.

Notes:
1. The frequency of the spent fuel element accident is obtained from the PRA (Table C.5.1.1.1-2).
2. The consequence estimates presented here for LOOP, Large LOCA, SWT, and FHA scenarios are based on calculations discussed in C.5.1.1.3.
3. The frequency of breaks greater than 13 inches is estimated based on arguments given in BNL 1990, BNL 1990b.
4. A D_2O release accident was postulated but was not evaluated in detail, and is not shown, because the involved worker would receive approximately 1 mrem from this accident, and noninvolved workers and the public would receive much less.
5. An Experimental Facility Accident comparable to the TRISTAN fire was postulated but was not evaluated in detail because its consequences were negligible.

Source: BNL 1993, BNL 1998f, Schmidt 1998, Wagage 1999, Palmrose 1999.

4.11.4 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

4.11.4.1 Normal Operations

Radiological Impacts: A prerequisite to HFBR reactor vessel replacement would be the removal of the existing vessel and the associated internal components. These activities would be performed consistent with maintaining personnel exposures as low as reasonably achievable (ALARA) and without damaging the lower thermal shield, which can be reused with the new vessel. Reactor vessel segmentation for ease of removal and shipping has been analyzed and considered (WMG nd). The following discussion assumes that the segmentation as described in that report would occur as planned.

Criteria for component segmentation is dependent on component activation. Component activation influences the shielding required to maintain personnel exposure ALARA, component waste classification, and selection of an appropriate disposal container. Components were divided into four groups based on expected anticipated radiation levels:

- Material for storage - these are items that have contact radiation levels in excess of 40,000 R/hr and exceed the 10 CFR 61 Class C and Hanford disposal site criteria. These components would have to be stored in the spent fuel pool until D&D. Transfer of these components into the pool would have to be performed remotely due to the dose rates associated with them. These components would account for approximately 780,000 Ci of the total activity.

- High activity material - these materials have expected contact radiation levels in the 400 to 40,000 R/hr range. These components would account for approximately 16,000 Ci of the total activity.

- Intermediate activity materials - these items have contact radiation levels in the 15 to 400 R/hr range. The components in this activity group would account for approximately 7,800 Ci.

- Moderate to low activity materials - these items may have contact radiation levels of up to 15 R/hr. These components account for a relatively small 5.5 Ci of activity

All of the above-mentioned items have a total weight of around 23,000 kg (50,000 lb) and associated total activity of slightly more than 800,000 Ci.

Though general removal sequences have been formulated that reflect ALARA concerns, individual doses to the workers will be determined by the particular method of segmentation, transportation, and shielding.

Although specific analyses of worker doses have not been performed for the enhance facility portion of this alternative, based on the above information, it is likely that worker doses will increase in comparison to other alternatives. The extent of the increase will depend on the implementation approaches used.

With regard to the reactor operations that would occur under this alternative, the radiological impacts to the public and worker would be the same as the impacts for the 60 MW Alternative (see Tables 4.11-6 and 4.11-7).

Hazardous Chemical Impacts: The chemical impacts for this alternative are the same as those for all the other alternatives when the reactor is operating. The amounts of chemicals stored at the facility are independent of the level of reactor power. The facility enhancements for this alternative are not expected to introduce any significant quantities of hazardous chemicals though some chemicals for decontaminating the removed reactor vessel and components will be needed. Thus the chemical impacts from this alternative would be small.

4.11.4.2 Facility Accidents

Based on information available, once the major component replacements and enhancement activities are complete, this alternative would not significantly change assessed accident frequencies or consequences from the 60 MW Alternative. This conclusion is reached based on an examination of the PRA's technical basis for its quantification of beam tube rupture (BTR) likelihood. The PRA indicates that the BTR probability would remain a small, essentially time-independent constant until appreciably more damage would have occurred in the beam tubes, at which time the assessed failure likelihood would begin to increase. Therefore the 60 MW Alternative impacts shown in Table 4.11-8 and discussed in Section 4.11.3.2 represent the impacts for the Resume Operations and Enhance Facility Alternative.

4.11.5 PERMANENT SHUTDOWN ALTERNATIVE

4.11.5.1 Normal Operations

Radiological Impacts: Initially, during the stage of this alternative that deals with the deactivation of the HFBR, activities are expected to be performed where workers will receive some doses. The environmental concern associated with these tasks is not expected to exceed that experienced during the years when the reactor has been shut down and defueled (see the No Action Alternative above), since some of the efforts necessary for this stage of the deactivation process have been performed to bring the reactor to the shutdown condition. The placement of the reactor in an industrially and radiologically safe condition would entail some radiological worker doses, primarily due to the efforts necessary to remove the radioactive systems and subsystems, equipment, and structures that are associated with the reactor. These efforts would also involve removing tritiated fluids, which would essentially eliminate tritium discharges from the HFBR. The worker doses associated with these efforts would be expected to be no greater than the doses that the workers received during the defueling phase. The doses to the offsite population would also be of a similar level.

During the time that the facility would be in long-term S&M, the impacts would be expected to only slightly decrease with time as the potential sources of radioactive release consist primarily of activated metals, and the radionuclides of greatest concern (for instance, Fe^{55}, Co^{60}, Ni^{63}, Zn^{65}) have relatively long half-lives. Although the activities performed during long-term S&M are similar to the activities performed for a shutdown, defueled reactor facility, because there would be no tritiated fluids remaining at the HFBR during the S&M period, the normal operation impacts associated with the S&M period are expected to be significantly less than the impacts associated with the No Action Alternative.

Hazardous Chemical Impacts: Initially, during the stage of this alternative that deals with the deactivation of the HFBR, some chemicals may be introduced into the facility for the purpose of decontaminating the HFBR. Individual impacts for the individual chemicals will have to be assessed on a case-by-case basis. Without knowing the specific chemicals to be used during deactivation, a definitive determination of the consequences on the worker or public cannot be made. However, large quantities of chemicals are typically not introduced during deactivation activities and the normal operation impacts to the public from these activities are expected to be small.

The chemical inventory not associated with deactivation activities would be reduced because some chemicals normally stored or used for treating process-associated systems would no longer be required. Therefore, sulfuric acid, cadmium nitrate, and some of the other chemicals would no longer be needed. The hazards associated with these chemicals would no longer be present at the HFBR. The only other chemicals present at the HFBR would be those not associated with operations (for example, those associated with housekeeping and air conditioning) and are expected to be in quantities commonly found in everyday working situations.

To the extent that the chemicals from the current shutdown condition remain onsite during the S&M phase, the impacts associated with these chemicals should be no greater than the chemical impacts from the No Action Alternative.

4.11.5.2 Facility Accidents

None of the accidents previously described directly pertains to the Permanent Shutdown Alternative. The core damage accidents cannot occur if there is no fuel in the facility. Scenarios that are functionally equivalent to the two lowest-consequence scenarios (D_2O spill and release from experimental facilities) could occur during a transition to a permanent shutdown state, but cannot occur once such a transition has been made. It is possible to have a spill of D_2O, but only so long as the D_2O is kept onsite. If a D_2O spill did occur, the involved worker would receive a dose of approximately 1.0 mrem, which would result in a probability of LCFs of $4x10^{-7}$, or 0.0000004 per accident for the worker. Similarly, it is possible to have a fire in the HFBR with the confinement building open, driving small amounts of radioactive material into the air, but only so long as the material is left in place. The impacts from this postulated event is expected to be extremely small.

4.12 WASTE MANAGEMENT

The following section analyzes the impacts on waste management for each alternative. The annual waste generation rate is estimated for each waste type within each alternative analysis. Impacts are evaluated by comparing the waste generation rates to the BNL waste storage capacities detailed in section 3.12.

4.12.1 ESTIMATING WASTE GENERATION RATES

The HFBR is a research reactor that generates wastes from both reactor operations and maintenance and scientific research. The estimate of waste generation for each alternative is based on recent historical waste generation rates. For all alternatives the industrial waste generation rate is estimated to remain constant since the HFBR generates such a small amount of this waste type.

4.12.1.1 Estimating Waste Generation for the No Action and Permanent Shutdown Alternatives

Annual waste generation rates for the No Action and Permanent Shutdown Alternatives were estimated based on the five-year average of waste generated by the HFBR between 1993 and 1997. These rates were then reduced to account for expected decreases due to lack of fuel handling, research experiments and reduced maintenance. Under the Permanent Shutdown Alternative, waste generation rates are expected to increase during the first two years as the facility is characterized and stabilized in preparation for final D&D.

4.12.1.2 Estimating Waste Generation for the Resume Operation and the Resume Operation and Enhance Facility Alternatives

Annual waste generation rates for the Resume Operation Alternatives and the Resume Operation and Enhance Facility Alternative were based on the five-year average of wastes generated by the HFBR between 1993 and 1997. The waste generation rate was modified to account for slight increases associated with 60 MW operation.

4.12.2 NO ACTION ALTERNATIVE

Under this alternative, the HFBR would remain in a shutdown condition indefinitely. No additional spent nuclear fuel elements will be generated under this alternative.

Solid LLW would continue to be generated by routine maintenance and monitoring of the facility. Initially, until all modification projects discussed in Section 2.3 are complete, waste would be generated at or above the average rate of 37 m^3 (1,300 ft^3) annually. However, once all repair and modification projects are complete, the annual waste generation rate is estimated to be about 23 m^3 (800 ft^3) per year. This is based on the assumption that no waste would be generated associated with fuel handling or research activities, on average 4 m^3 (140 ft^3) per year. It was estimated that the reduced maintenance and operations would result in generation of approximately half of the normal volume of compactable waste, or about 11 m^3 (400 ft^3) (Kneitel 1999).

Liquid LLW will continue to be generated at about the same rate as is currently generated. It is expected that with no fuel stored in the spent fuel pool the number of resin bed regenerations would be reduced by half. However, with no fuel in the spent fuel pool the evaporation rate and required makeup would be lower. More water is being collected and processed as LLW (air conditioner condensate) and this increase is expected to balance the decrease due to fewer regenerations. Therefore, the annual liquid LLW generation rate is expected to remain constant at the five-year average (1993-1997) rate of approximately 80 m^3 (21,000 gallons) annually.

It is estimated that reduced maintenance and monitoring requirements would result in a 25 percent reduction, from the five-year average

(1993-1997) rate in both mixed and hazardous waste generation. Approximately 1.3 m^3 (45 ft^3) of mixed waste and 1.8 m^3 (65 ft^3) of hazardous waste would be generated annually.

The industrial waste generation rate is estimated to remain constant as the HFBR contributes such a small amount to this waste stream.

4.12.3 RESUME OPERATION ALTERNATIVE – 30 MW POWER LEVEL

Under this alternative, the HFBR would be refueled and operated at 30 MW. At maximum yearly operation, the HFBR could potentially generate a maximum of 77 spent fuel elements a year. This is based on replacing 7 elements each cycle, using a nominal cycle length of 30 days and a minimum shutdown time of 3 days, for a total of 11 cycles a year (BNL 1998i). Historically, no more then 9 operating cycles have been run during one year. Therefore it is likely that no more then 63 spent fuel elements would be generated annually. In addition, the entire core (28 elements) would be discharged approximately once every 5 years to facilitate material surveillance of the reactor vessel.

Solid and liquid LLW would be generated at the same rates as the average in the five-year period between 1993 and 1997. The volume of solid LLW generated would be approximately 37 m^3 (1,300 ft^3) annually. Liquid LLW would continue to be generated at a rate of approximately 80 m^3 (21,000 gal) annually.

Mixed waste would be generated at approximately 1.7 m^3 (60 ft^3) annually, the same rate as in the five-year average.

Hazardous waste would be generated at approximately 2.4 m^3 (85 ft^3) annually, the same rate as in the five-year average.

The industrial waste generation rate is estimated to remain constant as the HFBR contributes such a small amount to this waste stream.

4.12.4 RESUME OPERATION ALTERNATIVE – 60 MW POWER LEVEL

Under this alternative, the HFBR would be refueled and operated at up to 60 MW. At maximum yearly operation the HFBR could potentially generate up to 158 spent fuel elements annually. This is based on replacing 14 elements each cycle, using a nominal cycle length of 24.5 days and a minimum shutdown time of 8 days, for a maximum of 11 cycles (BNL 1998i). It is anticipated that the actual number of spent fuel elements would be less then this because as in the 30 MW scenario, fewer cycles are likely to be run. In addition, the entire core (28 elements) would be discharged approximately once every 5 years to facilitate material surveillance of the reactor vessel.

Solid LLW would be generated at slightly higher rates then during the five-year period between 1993 and 1997. Cut fuel ends and other fuel handling waste is expected to contribute an additional 5.0 m^3 (175 ft^3), so that, at 60 MW, the estimated volume of solid LLW generated would be 42 m^3 (1,475 ft^3) annually. Liquid LLW would continue to be generated at a rate of approximately 80 m^3 (21,000 gallons) annually.

It is anticipated that mixed and hazardous wastes would continue to be generated at the same rates as 30 MW operation (approximately 1.7 m^3 (60 ft^3) of mixed waste and 2.4 m^3 (85 ft^3) of hazardous waste annually).

The industrial waste generation rate is estimated to remain constant as the HFBR contributes such a small amount to this waste stream.

4.12.5 RESUME OPERATION AND ENHANCE FACILITY ALTERNATIVE

Under this alternative, the HFBR would resume operation at up to 60 MW and eventually the facility would be upgraded. Upgrades could include replacement of the reactor vessel, beam tubes and experimental equipment.

As a result of the upgrades, there would be a one-time increase in the volume of solid LLW generated. It is estimated that disposal of the replaced components would result in the generation of 15 m^3 (500 ft^3) of non-compactable metal waste. In addition, the construction work would generate 15 m^3 (500 ft^3) of compactable solid waste in the form of anti-contamination clothing. It should be noted that some of this increase might be offset by waste that is not generated during normal operations such as fuel handling, etc.

With the exception of this one-time increase in solid LLW, all waste generation rates would be the same as those estimated for the Resume Operation-60 MW Power Level Alternative.

4.12.6 PERMANENT SHUTDOWN ALTERNATIVE

The Permanent Shutdown Alternative would involve permanent termination of HFBR operations and placement of the reactor in an industrial and radiologically safe condition prior to D&D. Although additional environmental reviews to examine the impacts of D&D would be required prior to the commencement of D&D, some wastes would be generated as a result of characterization and stabilization of the facility.

No additional spent fuel elements would be generated under this alternative.

Solid LLW is expected to increase in the first year or two as the facility is characterized and stabilized. Some non-reactor components may be removed and disposed. It is estimated that the amount of solid LLW generated during the first year or two of permanent shutdown could be as much as two to three times that of the No Action Alternative or approximately 57 m^3 (2,000 ft^3) a year. After that, reduced monitoring and maintenance would result in roughly half of the waste generated during the No Action Alternative or 11 m^3 (400 ft^3) annually until the D&D activities commence.

Liquid LLW is also expected to increase in the first year or two after permanent shutdown as systems are drained in preparation for D&D. Approximately 42 m^3 (11,000 gal) of heavy water would be drained from the reactor primary coolant system and other support systems. It is most likely that the heavy water would be recycled for use in a variety of other research applications. An additional 38 m^3 (10,000 gal) of water drained from other HFBR support systems will also need to be processed as liquid LLW. Once the heavy water is removed from the facility, the airborne tritium levels are expected to decrease dramatically. As a result, the air conditioner condensate and other liquids from the building would no longer be radioactive waste. This should result in a reduction of half the generation of liquid LLW to 38 m^3 (10,000 gal) annually. Some liquid LLW would still be generated as a result of regeneration of resins since the spent fuel pool will be used to store radioactive components such as the reactor vessel internals.

Mixed waste generation would increase during the first year or two after permanent shutdown as a result of the disposal of contaminated lead and items such as the beam tube plugs. As much as 15 m^3 (500 ft^3) of mixed waste could be generated during this time. However, the volume of mixed waste should decrease once the facility characterization is complete and the facility is stabilized. It is estimated that after the first two years, roughly half as much mixed waste would be generated compared to the No Action Alternative, or 1 m^3 (35 ft^3) annually.

Hazardous waste generation may increase during the characterization and stabilization of the facility as lead and other heavy metals are removed from the HFBR. This could potentially result in as much as twice the normal waste generation rate for the first year or two, approximately 5.7 m^3 (200 ft^3). After this time period only about half of the volume of hazardous waste generated under the No Action Alternative, or 1.0 m^3 (35 ft^3), would be generated annually.

The industrial waste generation rate is estimated to remain constant as the HFBR contributes such a small amount to this waste stream.

4.12.7 WASTE MANAGEMENT IMPACTS

Table 4.12-1 compares the existing storage capacities with the expected annual generation rates for each alternative. Note that BNL does not dispose of any solid wastes onsite, it only stores and packages them for transport offsite to approved treatment and disposal facilities. Therefore, the environmental impacts of each alternative are evaluated by comparing the waste generation rates of each alternative to BNL's storage capacity and ability to package and transport each waste type.

As Table 4.12-1 indicates, the maximum impact on the Waste Management Facility would not exceed 30 percent of BNL's waste storage capacity (liquid LLW) and in most scenarios is much less. Considering that BNL only stores its wastes temporarily and that BNL has ample capacity to accommodate the expected waste generation rates for each alternative, the wastes generated by any alternative would pose no significant impact on BNL waste management.

Table 4.12-1. Estimated Annual Waste Generation For the HFBR Alternatives

Category	No Action	Resume Operation 30 MW	Resume Operation 60 MW	Resume Operation & Enhance Facility	Permanent Shutdown	BNL Storage Capacity
SNF	0	77 max.[c]	158 max.[c]	158 max.[c]	0	1000 elements
Low Level Radioactive Waste						
Liquid	80 m^3	80 m^3	80 m^3	80 m^3	38 m^3 [b]	265 m^3
% Capacity	30%	30%	30%	30%	15%	
Solid	23 m^3	37 m^3	42 m^3	42 m^3 [a]	11 m^3 [b]	540 m^3
% Capacity	4.3%	6.9%	7.8%	7.8%	2.0%	
Mixed	1.3 m^3	1.7 m^3	1.7 m^3	1.7 m^3	1.0 m^3 [b]	19 m^3
% Capacity	6.8%	8.9%	8.9%	8.9%	5.2%	
Hazardous	1.8 m^3	2.4 m^3	2.4 m^3	2.4 m^3	1.0 m^3 [b]	117 m^3
% Capacity	1.5%	2.1%	2.1%	2.1%	0.9%	
Industrial	Industrial waste generation expected to remain constant under all alternatives.					NA

[a] This value does not include a one-time increase of 30 m^3 (1,000 ft^3) due to enhancement of the facility.
[b] During the first two years of this alternative the expected waste generation is: Solid LLW 60 m^3 (2,000 ft^3), Mixed waste 15 m^3 (500 ft^3), Hazardous waste 5 m^3 (170 ft^3), in addition a one time generation of Liquid LLW from the draining of the HFBR systems in preparation for D&D of 42.0 m^3 (11,000 gal) of heavy water and 38.0 m^3 (10,000 gal) light water.
[c] An additional 28 elements will be generated approximately once every five years.

4.13 ENVIRONMENTAL JUSTICE

None of the alternatives would have environmental justice impacts because there would be no substantial economic or health impacts to any potentially affected population (refer to Sections 4.9 and 4.11). Therefore, there would be no disproportionate adverse impacts to either low-income or minority populations.

4.14 CUMULATIVE IMPACTS

This section of the EIS analyzes potential cumulative impacts that might reasonably be expected to occur as the result of an HFBR alternative. A cumulative impact is an "impact on the environment which results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). Thus, cumulative effects result from reasonably foreseeable future actions when added to the effects of past and current actions regardless of the cause.

The scope of this cumulative effects analysis is based on the direct impact analysis presented in Chapter 4 of this EIS, consultation with government agencies having knowledge of ongoing and future actions affecting the resources of concern, and planned or proposed actions identified in BNL planning and NEPA documentation.

Because the HFBR is an existing facility and no new construction is associated with any of the EIS alternatives, socioeconomic and cultural effects — which usually occur as the result of construction related activities — are not addressed in this cumulative effects analysis. Similarly, impacts to physical and biological resources, including human health, generally occur from two causes: consumption of resources, and effluent emission streams to the environment. However, the quantity of resources consumed by the HFBR, including groundwater for cooling, fossil fuels for facility heating and cooling, and nuclear fuel for the operation of the reactor, are available well in excess of the needed quantities.

The resources and impact areas that were identified for analysis include air and groundwater quality, radiological waste management, and associated human health effects. The HFBR's contribution to potential cumulative effects for the other resources, as described earlier in this EIS, either does not occur or is so small that the HFBR contribution does not warrant analysis for cumulative effects.

The three State agencies responsible for issuing permits and licenses for the use and emission of radiological materials (NYSDES, NYSDOH, and New York State Department of Transportation [NYSDOT]) were contacted. No other existing or reasonably foreseeable future radiological emission sources were identified within ten miles of BNL. The nearest facility that discharges radioactive material to the environment by any pathway is the State University of New York at Stony Brook, which is approximately 25 km (16 mi) northwest of BNL. The University does not require a permit from NYSDEC because their emissions are lower than the NYSDEC permitting threshold (NYSDEC 1998).

The Town of Brookhaven identified various private and municipal projects planned in the vicinity of BNL. None of the projects affect resources of concern for this cumulative effects analysis.

Two onsite projects planned for completion in 1999 were included in this analysis: programmed improvements of the AGS complex and completion of RHIC. The proposed Booster Applications Facility (BAF) for which an Environmental Assessment (EA) was prepared in 1998 has also been considered (DOE 1998). Another action considered in this cumulative effects analysis is the former alternative proposal for locating a Spallation Neutron Source (SNS) at BNL. DOE has since decided to locate SNS at the Oak Ridge National Laboratory (64 FR 35140).

4.14.1 AIR QUALITY

This section describes the anticipated incremental effects of HFBR operation and reasonably foreseeable future air quality impacts with the potential for significant cumulative effects.

4.14.1.1 Past Actions

As discussed previously in Section 3.4.2.1, BNL is a well-ventilated site. As a result, the residual effects of past actions are not likely to be evident in BNL's current air quality. Previously constructed BNL facilities which may be sources of current air emissions are reflected in BNL's existing ambient air quality.

4.14.1.2 Present and Future Actions

As described in Section 4.11 and in the BNL *Site Environmental Report* (BNL 1996a), BNL is subject to the requirements of Title 40 CFR Part 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants* (NESHAP). The computer modeling performed by BNL to comply with NESHAP supplies both the calculated committed effective dose equivalent (CEDE) to the MEI (a hypothetical individual living at the site boundary), and the collective population dose within an 80 km (50 mi) radius of the emission sources (BNL 1996a).

Radiological air emissions are monitored throughout the year and reported in the annual BNL *Site Environmental Report*. Onsite emission sources and monitored radiological concentrations are discussed in Section 4.11 of this EIS. As discussed in Section 4.11, HFBR radiological air emissions, principally tritium, would be released primarily from the HFBR stack. As described in Section 4.11.3.1, the incremental contribution of these releases under 60 MW operation would be approximately 5.6×10^{-4} (or 0.00056) mrem/yr to the MEI.

Operation of BAF, the improvements to the AGS, and the operation of RHIC and SNS — had SNS been sited at BNL — have the potential to add to the cumulative effects to radiological air quality. The potential cumulative effects on radiological air quality are characterized by degraded air quality caused by an increase in the concentration of radiological contaminants. The greater the increase in concentration, the higher the potential radiological dose to affected populations. The higher the dose, the higher the potential for LCFs.

BAF could produce air activation products in small quantities through interaction of the beam with air in the target hall. Potentially, tritium, Be^{7}, C^{11}, N^{13}, O^{14}, O^{15}, and Ar^{41} could be produced. At a frequency of less than once per year, it may be necessary to vent the target hall causing release of the generated air activation products. As a result of a target hall release, the MEI at the site boundary could potentially receive a dose of 9.0×10^{-5} (or 0.00009) mrem/yr (DOE 1998).

Airborne releases from the AGS (with all improvements) under maximum intensities and energies could potentially result in a maximum offsite dose equivalent of approximately 0.3 mrem/yr (DOE 1994).

RHIC would be expected to produce a number of air activation products including tritium. Tritium quantities released to the atmosphere are estimated to be 1.3×10^{-4} (or 0.00013) Ci/yr. The maximum dose to an individual resident at the site boundary as a result of all radionuclide air releases from RHIC operation could potentially be expected to be 0.016 mrem/yr (DOE 1991).

Radiological air emissions for the SNS — had the SNS been located at BNL — during operations would primarily be ventilation air from the linac tunnel, accumulator rings, and target building. The target building exhaust would include emissions from the cooling system, target off-gas, and beam dumps. Tunnel confinement exhaust would include emissions from the linac, ring, and beam transfer tunnels. The 4 MW operation level would generate the highest levels of radionuclides and is used in this analysis to bound potential cumulative impacts. The projected annual emissions of radionuclides from the target building exhaust would be about 1,425 Ci, mostly from Ar^{37} (approximately 1,000 Ci). Annual tritium emissions would equal approximately 100 Ci. Tunnel confinement exhaust would be about 1,235 Ci annually, mostly from N^{13} (about 480 Ci) and O^{15} (about 520 Ci). No tritium would be released from tunnel confinement exhaust (DOE 1999a). These emissions could potentially result in doses to the MEI of approximately 3.4 mrem/yr (DOE 1999a).

4.14.1.3 Summary

As discussed in Section 4.11.1.1, the offsite dose to the MEI while HFBR is shutdown (No Action Alternative) is 8.0×10^{-5} (0.00008) mrem/yr. Cumulative dose (No Action baseline+HFBR+ BAF+AGS+RHIC+SNS) to the MEI if the HFBR were operating at 60 MW could be approximately 3.7 mrem/yr. This is well below 10 mrem/yr, the NESHAP standard for DOE facilities (40 CFR 61, Subpart H), which was established by the EPA as a national standard to protect human health. Consequently, cumulative radiological air emissions would not be significant.

4.14.2 WATER QUALITY

As discussed in Section 3.5.2, BNL lies within the Peconic River watershed, which overlies six strata of aquifers. The aquifer nearest the surface, the Upper Glacial Aquifer, produces the largest volume of water for domestic use. Wells completed in this aquifer can yield in excess of 3,800 lpm (1,000 gpm). Much of the public drinking water supply for Suffolk County is drawn from this source (BNL 1997).

4.14.2.1 Past Actions

Past actions at BNL have led to the contamination of groundwater in several locations around the site. With regard to the HFBR, leakage from the spent fuel pool has led to the contamination of an area of the groundwater resource within the BNL site boundary. These past actions and the resulting impact to the resource are described in Section 3.5.2 of this EIS.

4.14.2.2 Present and Future Actions

As described in Section 3.5.2, actions taken to address releases of tritium to groundwater (including installation of the spent fuel pool liner) will reduce, if not eliminate, the potential for uncontrolled releases. Operating at 60 MW, only small amounts of tritium (up to 3,000 pCi/l) would be likely to reach groundwater as a result of HFBR cooling water releases to recharge basins and potential leaking sewer lines.

Reasonably foreseeable actions that could add to cumulative impacts to groundwater resources in the vicinity of the HFBR include BAF, the improvements to the AGS, completion of RHIC, and operation of SNS, had the SNS been sited at BNL.

BAF would not involve the discharge of radiological materials to groundwater. However, radionuclides could be created in soil particles within the first meter of soil beneath the target and beam stop shields. By the time water could leach the radionuclides from the soil particles from beneath the facilities, move into ground water, and migrate to any onsite or offsite potable water supply well, these radionuclides would be expected to have fully decayed and not be detectable above background concentrations (DOE 1998).

With regard to the AGS improvements, discharges of Be^7 and Mn^{54} would be expected to increase to approximately 60 pCi/l and 0.8 pCi/l, respectively. Discharges to recharge basins may potentially produce an annual CEDE of 0.006 mrem/yr from Be^7 and 0.002 mrem/yr from Mn^{54} for a total of 0.008 mrem/yr to the affected individual using Basin HN (the discharge point for AGS water effluent) as a sole source of drinking water. However, this basin is not used as a source of drinking water (DOE 1994). Tritium is not a contaminant expected to be released as a result of the AGS improvements.

During operation of RHIC, secondary particles created by beam interactions could escape into the soil surrounding the tunnel. Some of these particles would interact with the silicon and oxygen atoms present in the soil. Radionuclides typically created by these processes include tritium, of which less than 11 mCi are produced each year, that could contribute to potential human exposure. RHIC would be expected to add less than 0.0001 mrem/yr as a result of tritium contamination of the groundwater. At the closest potable water well (#11), contamination of groundwater from RHIC operation (which includes tritium and other radionuclides such as sodium-22) could potentially add 0.14 mrem/yr to individual onsite doses if this were the only source of drinking water (DOE 1991).

SNS liquid effluent discharges would have occurred, had the SNS been located at BNL, as a result of cooling tower blowdown, any groundwater that might collect in the groundwater interceptor system under the concentric shielding design, and storm water runoff from the SNS site. Only groundwater collected in the interceptor system has the potential to contain radionuclides. Although calculations for concentrations and transport for the SNS at BNL have not been performed, "radionuclide contamination of groundwater would be an important potential effect of the proposed SNS facility operations" (DOE 1999a).

Current groundwater remediation activities at BNL are expected to continue and are likely to expand. As a result, and assuming no additional unanticipated contribution of contaminants, concentrations of contaminants in the groundwater resource in the vicinity of the HFBR should show measurable decreases.

4.14.2.3 Summary

Incremental contribution of tritium releases to groundwater from operation of the HFBR at 60 MW (the Resume Operations Alternative and the Resume Operation and Enhance Facility Alternative) would be small. The direct potential impact on water quality from HFBR discharges are described in Section 4.5.3.2. No release from the spent fuel pool or as a result of normal maintenance would be anticipated. Cooling water discharges to recharge basins and potential leakage from sanitary sewer lines would also be expected to contain small amounts of tritium (up to 3,000 pCi/ℓ).

Because the source of the discharges that contaminated the groundwater under the HFBR will be eliminated, and because the potential future HFBR discharges and other actions that could contribute to cumulative impacts on groundwater resources in the vicinity of the HFBR are minor, no significant cumulative effects to groundwater resources would be expected from operating the HFBR at the 60 MW level.

4.14.3 Radiological Waste Management

Radiological waste management is performed by various groups and units at BNL, as discussed in Section 3.12 of this EIS. Facilities for handling, storage, treatment, and packaging for disposal of radioactive wastes are contained in the newly constructed WMF and in Building 811 (low-level liquid waste storage). Storage capacities for BNL facilities provide approximately 540 m^3 (19,000 ft^3) of low-level solid waste, 287,700 ℓ (76,000 gal) of low-level liquid waste, and 19 m^3 (670 ft^3) of mixed waste (Todzia 1998, Kneitel 1999).

The design of the new WMF was directed at eliminating areas of regulatory nonconformance that existed in the operation of the old facility. These design features chiefly involve the use of work areas of sufficient capacity to meet laboratory demands, and with environmental protection features designed to prevent the migration of hazardous chemicals and radioactive materials into the surrounding environment. In the area of radioactive waste handling, the new facility is of sufficient size to avoid the past practice of outdoor storage and staging of bulk materials. This reduces the potential for radioactive material to be leached into the surrounding soil and groundwater.

4.14.3.1 Past Actions

Past actions related to radiological waste management have resulted in several areas of contamination that adversely affected groundwater to the extent that the water quality exceeds drinking water standards and is not suitable for potable uses. Remedial activities are underway at BNL to address many of the groundwater contamination concerns caused by past waste management activities. Section 3.5.2.4 describes ongoing remediation.

4.14.3.2 Present and Future Actions

Annual radiological waste generated by the HFBR varies from year to year. However, the average radiological waste volumes generated for 1993 through 1997 are considered representative for the 30 MW level of operation, and only relatively small increases in solid LLW (approximately 2 m^3) would be expected for 60 MW operations. The small increase in solid LLW would account for additional wastes produced by preparations for increased fuel element handling activities and an increase in fuel element cut ends. The 1996 radiological waste volumes for the HFBR are shown in Table 4.14.-1.

Annually, BNL collects approximately 200 m^3 (7,000 ft^3) of solid LLW, 150 m^3 (40,000 gal) of liquid LLW, and 5 m^3 (185 ft^3) of mixed waste (BSA 1998). All of BNL's LLW and mixed waste is disposed offsite, and thus becomes a very small increment of total DOE LLW and mixed waste volumes for disposal. For example, BNL shipped approximately 34 m^3 (1,200 ft^3) of solid LLW to the Hanford Site in Washington in September 1998 (Todzia 1998). This shipment was a small portion of the approximately 4,800 m^3 received for disposal at Hanford in 1998 (less than 1%) (Hanford 1998).

Other options for waste disposal are also available to BNL. For example, the Nevada Test Site lists BNL as an approved generator and projects LLW shipments for disposal from BNL to be approximately 3,300 m^3 (127,000 ft^3) over the next 10 years (DOE 1996a). While DOE relies primarily upon its own facilities for the disposal of its LLW and mixed waste, in recent years DOE's use of commercial disposal facilities has increased, and greater use of commercial facilities may occur as DOE proceeds with the cleanup of its sites (DOE 1999b).

Reasonably foreseeable future actions at BNL that can be expected to affect the cumulative volume of waste needing treatment, storage, and disposal are the BAF, improvements to the AGS, completion of RHIC, and the formerly proposed operation of SNS at BNL.

BAF is expected to contribute approximately 1.5 m^3 (53 ft^3) of solid LLW as a result of routine maintenance and possibly the occasional need for replacement of broken or malfunctioning beamline components (DOE 1998).

With regard to the AGS, improvements would reduce the amount of beam lost under maximum operating intensities and energies from 35 percent to 3 percent. This would translate into a reduction of LLW generation because the reduction of equipment exposures would decrease the frequency with which the equipment would require replacement. Over time, total volume of radioactive waste generated would decrease by up to 20 percent as equipment maintains its reliability due to decreased radiation exposure (DOE 1994). Annual generation of radioactive waste (solid LLW) from the upgraded AGS would be approximately 50 m^3/yr (1,800 ft^3/yr) (DOE 1994).

RHIC LLW would be shipped to and disposed of through burial offsite as described above. Operation of RHIC would be expected to add approximately 9 m^3/yr (300 ft^3/yr) to BNL's total (DOE 1991).

Table 4.14-1.
HFBR Annual Average Radiological Waste Generated

Year	Solid LLW	Liquid LLW	Mixed Waste
1993-1997	37 m^3	80 m^3	1.7 m^3

Source: BNL 1998i.

Table 4.14-2. Annual Radioactive Waste Generation by the SNS

Low-Level Radioactive Waste	
Liquid	665 m^3
Process waste (potentially LLW)	15,719 m^3
Solid	1,206 m^3
Mixed Waste	
Liquid	10.8 m^3
Solid	7 m^3

Source: DOE 1999a

Radioactive wastes generated by SNS — had SNS been sited at BNL — would include LLW and mixed waste. Radioactive waste volumes are included in Table 4.14-2.

D & D Waste: Although the volume of waste has not been estimated for eventual HFBR D&D under any alternative, the waste volume expected to be produced during D&D of the S1C, S3G, and D1G Prototype reactors can be used as surrogate data because they are relatively similar in size to the HFBR. Each of the prototype reactors is small in comparison to commercial reactor plants, as is the HFBR. After completion of all segregation, recycling, volume reduction processing, and efficient packaging of materials, S3G and D1G Prototype reactor plant dismantlement would generate approximately 450 m^3 (16,000 ft^3) of low-level radioactive wastes that would require disposal (DOE 1997c). Similarly, after completion of all segregation, recycling and volume reduction processing initiatives, S1C Prototype reactor plant dismantlement would generate approximately 76 m^3 (2,700 ft^3) of low-level waste that would require disposal (DOE 1996b). In comparison, decommissioning of the Shippingport pressurized water reactor plant (a small plant by commercial standards) produced approximately 6,100 m^3 (220,000 ft^3) of low-level radioactive wastes (DOE 1997c). Depending on the methods and techniques selected, volumes of waste for HFBR D&D can be expected to be similar to the S1C, S3G, and D1G reactors, and much less than the Shippingport reactor. It is likely that the wastes would be generated over the course of several years with consideration given to BNL's ability to manage and process the waste.

Prior to initiating any D&D activities for the HFBR, an appropriate environmental review would be performed to assess the impacts such actions would have on BNL's waste management capabilities. Although simultaneous D&D activities of other facilities might be underway at the time of HFBR D&D, the pace of the activities associated with all site D&D would likely be dictated by BNL's waste management capabilities at that time. To avoid exceeding the BNL capacity, HFBR D&D would have to be spread over at least two years. This assumes the 450 m^3 (16,000 ft^3) volume (surrogate data) is being added to average annual volumes plus BAF, AGS, RHIC and SNS volumes. However, it is likely that D&D would require a longer time frame, thus lessening the potential impact on BNL waste management capacity.

4.14.3.3 Summary

As discussed in section 4.12, average annual HFBR radioactive waste volumes for normal operations would not be expected to greatly exceed the 1996 levels, the last year the reactor was in full operation. The annual HFBR radiological waste volumes under 60 MW operating levels (the Resume Operations Alternative and the Resume Operations and Enhance Facility Alternative) would be expected to be well below 50 percent of BNL's storage capacity. However as shown in Table 4.14-3, cumulative volumes from all foreseeable actions, which includes the formerly proposed operation of SNS at BNL, exceed the capacity for mixed waste storage, and greatly exceed the solid and liquid LLW storage capacities of BNL's waste management facilities. Therefore, the cumulative impact of the waste volumes generated would be significant. However, if

SNS waste volumes are not included, the cumulative impact of the waste volumes generated would not be significant.

D & D Waste: The number and extent of D&D activities during the next few decades is uncertain. There are several facilities at BNL that will require D&D. These include facilities such as the BGRR, which has been idle since 1968, and various structures (nine buildings) associated with the former HWMF whose operations have been transferred to the new WMF. No waste volume estimates nor time frames have been developed for all BNL facilities requiring D&D. It is very likely, however, that D&D activities will be undertaken, and many completed, in the next several years. The effect of uncertainty in assessing the impact of D&D operations (per 40 CFR 1502.22) is that annual waste volumes are not available for comparison with BNL's capacity for managing the waste. The radiological waste volumes expected to be generated for all D&D during the next several years would likely greatly exceed BNL's waste management facilities single year capacity, which would cause significant impacts if they occurred over a very short period (for example, in a single year). However, as indicated previously, D&D operations generally occur over the course of several years, which allows for the planning of waste volume generation that would be compatible with BNL's ability to manage the waste. Consequently, the associated cumulative impacts should not be significant.

Table 4.14-3.
Expected Annual Cumulative Radiological Waste Generated at BNL

Generator	Solid LLW	Liquid LLW[a]	Mixed Waste
Site-wide volume without HFBR contribution	162.5 m^3	49 m^3	4.72 m^3
HFBR	37.5 m^3	101 m^3	0.28 m^3
RHIC	9 m^3	N/A	N/A
AGS Upgrade	50 m^3	N/A	N/A
BAF	1.5 m^3	0	0
SNS	1,206 m^3	16,384 m^3 [b]	17.8 m^3
Cumulative Total	1,466.5 m^3	16,534 m^3	22.8 m^3
Total Storage Design Capacity for BNL Site	540 m^3	288 m^3	19 m^3
Remaining Capacity (over capacity)	(926.5 m^3)	(16,246 m^3)	0.2 m^3

a. 264 gal = 1 m^3
b. Includes 15,758 m^3 of process wastes that are potentially LLW.
N/A = Not Available
Source: DOE 1991; DOE 1994; DOE 1998; DOE 1999a; BSA 1998; BNL 1998i; Todzia 1998.

4.15 UNAVOIDABLE ADVERSE IMPACTS

Section 102(2)(c)(ii) of NEPA requires agencies to include in their "detailed statement" (the EIS) "any adverse environmental effects which cannot be avoided should the proposal be implemented." This requirement does not distinguish between impacts based on their potential "significance." Rather, it requires a full accounting of impacts with negative implications for the restoration and maintenance of environmental quality as described in Section 101 of NEPA.

The release of radioactive emissions would be an unavoidable adverse consequence of HFBR operations (Resume Operation Alternatives and Resume Operations and Enhance Facility Alternative). Radioactivity, primarily tritium, would be released in air emissions from the HFBR stack and in trace amounts from the cooling towers. These emissions would have a minor adverse impact on air quality. Small amounts of tritium also would be contained in liquid effluents piped to the STP and subsequently discharged (per SPDES permit) into the Peconic River. HFBR effluent emissions would have a very small adverse impact on Peconic River water quality. Trace amounts of tritium may also be contained in cooling water discharged to Recharge Basin HO. These discharges would have a minor adverse impact on groundwater quality.

Radiological emissions also would have a small impact on human health. Operating the HFBR at its highest power level of 60 MW would result in small increases in the annual doses to the MEI, the population, and the worker (0.00048 mrem, 59 person-mrem, and 105 mrem, respectively) in comparison to the No Action Alternative. These dose increases would result in very small increases in the probability of a latent cancer fatality (the population would be expected to have an additional 0.00003 latent cancer fatalities and the workers would be expected to have an additional 0.004 latent cancer fatalities).

Another unavoidable consequence of operating the HFBR would be the generation of waste. Radioactive, hazardous, and industrial waste would be generated under all alternatives. Spent nuclear fuel would be generated from HFBR operation. None of BNL's waste management capacities would be exceeded by the volumes that would be generated. Offsite facilities that treat and dispose of wastes would have decreased capacities to accommodate wastes that might be generated by BNL. However, the volumes involved would represent a very small increment of the total capacity of all offsite facilities (either DOE or commercial) that treat and dispose of wastes. As a result, adverse impacts would be very small.

The generation of waste also would be an unavoidable consequence associated with eventual D&D of the HFBR (Permanent Shutdown Alternative). The volumes generated and any adverse impact on BNL's ability to manage wastes would depend on the D&D actions selected. These wastes would decrease offsite treatment and disposal capacity, but the adverse impact would not be expected to be large.

4.16 RELATIONSHIP BETWEEN LOCAL/ SHORT-TERM USES OF THE ENVIRONMENT AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Section 102(2)(C)(iv) of NEPA requires agencies to include in their “detailed statement” (the EIS) "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity." Relationships whereby short-term uses diminish long-term productivity are of particular concern. Using the current lexicon, a successful relationship between current and long-term use is termed "sustainable development."

None of the EIS alternatives for the future of the HFBR involve construction activities on disturbed or undisturbed land area at BNL. Therefore, no new land areas would be committed that would preclude their use from future development.

The unavoidable generation of waste associated with any of the alternatives would require a commitment of land area (located at offsite DOE or commercial facilities) for waste disposal. The disposal of radiological wastes, particularly spent nuclear fuel, would likely preclude sustainable development or productive use of the land area used for disposal. The long-term productive use of areas used for hazardous waste disposal also would likely be diminished.

The eventual D&D of the HFBR facility would allow use of the land for other productive purposes depending on the D&D approach selected and the level of decontamination achieved. However, radioactive wastes generated by D&D activities would also require offsite land for disposal, thus, precluding the sustainable development of this land is likely.

4.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Section 102(2)(C)(v) of NEPA requires agencies to include in their “detailed statement” (the EIS) "any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." In addition, the CEQ regulations direct agencies to include discussions of "energy requirements" and "natural or depletable resource requirements" (40 CFR 1502.16(e) and (f), respectively). The focus of resource commitments is on those that are depletable (for example, fossil fuels and cultural resources). The irretrievable commitment of a depletable resource refers to the use or consumption of resources that are neither renewable nor recoverable for later use by future generations.

None of the HFBR alternatives involve construction efforts that would consume natural or depletable raw materials or fuel. Operation of the HFBR would involve consumption of fossil fuels (No. 6 fuel oil and natural gas) and electricity generated offsite to supply the steam and power necessary for lighting, heating, air conditioning, and other systems and activities associated with HFBR operations. The amounts consumed would not be expected to exceed historic usage, and would represent only a small portion of total BNL requirements.

Nuclear fuel would be consumed for alternatives that would involve operation of the HFBR (Resume Operation Alternatives and Resume Operation and Enhance Facility Alternative). The fuel elements for the HFBR are made from highly enriched uranium. At 30 MW operation, a maximum of 77 fuel elements would be consumed annually. At 60 MW, a maximum of 158 fuel elements would be consumed annually. This amount of fuel represents 30 kg (65 lb) and 60 kg (130 lb) of material, respectively. HFBR spent fuel elements would be irreversibly contaminated with radioactivity, and would not be reprocessed to recover usable uranium. The spent fuel elements would be shipped offsite for disposition as spent nuclear fuel. The spent fuel and the associated uranium would be irretrievable. The land area required for disposal of the spent nuclear fuel and other radioactive wastes from operation of HFBR would, for all intent and purposes, be irreversibly contaminated and irretrievable for future uses other than radioactive waste disposal.

Under the Resume Operation and Enhance Facility Alternative, a new upper thermal shield and reactor vessel, including experimental beam tubes and reactor vessel internals, would be installed. Operation of the HFBR would irradiate the material in these new components, irreversibly contaminating them with radioactivity. These materials, primarily metal, would be irretrievable for other uses, and would require disposal as radioactive waste.

4.18 REFERENCES

64 FR 35140 (Volume 64 Federal Register page 35140), 1999, "Record of Decision for the Construction and Operation of the Spallation Neutron Source", Volume 64, Number 125, U.S. Department of Energy, Washington, D.C., pp. 35140–35142, June 30.

29 CFR 1910 Occupational Safety and Health Administration, "General Industry Standards for Toxic and Hazardous Chemicals," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, July 1, 1997.

40 CFR 61 EPA, "Protection of the Environment: National Emission Standards for Hazardous Air Pollutants, Subpart H--National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, July 1, 1997.

40 CFR 1500 – 1508 CEQ, "Protection of the Environment: Regulations for Implementing the Procedural Provisions Of the National Environmental Policy Act," *Code of Federal Regulations*, Office of the Federal Register, National Archives and Records Administration, U.S. Government Printing Office, Washington, DC, July 1, 1997.

BNL 1964 Hendrie, J.M., *Brookhaven National Laboratory, Final Safety Analysis on the Brookhaven High Flux Beam Research Reactor*, Associated Universities., BNL-7661, Upton, NY, 1964.

BNL 1989 BNL, *Brookhaven National Laboratory Site Report for Calendar Year 1988*, BNL-52207, prepared by BNL Safety and Environmental Protection Division, Upton, NY. June 1989.

BNL 1990a Azarm, M.A. et al., *Level 1 Internal Event PRA for the High Flux Beam Reactor, Volume 1: Summary and Results*, Revision 1, prepared by Department of Nuclear Energy, BNL. July 1990.

BNL 1990b Azarm, M.A. et al., *Level 1 Internal Event PRA for the High Flux Beam Reactor, Volume 2: Detailed Analyses and Appendices*, Revision 1, prepared by the Department of Nuclear Energy, BNL, Upton, NY. July 1990.

BNL 1993 Hanson, A. et al., *Levels 2 and 3 Internal Events PRA for the High Flux Beam Reactor*, Revision 1, Prepared by Department of Nuclear Energy, BNL, May 1993.

BNL 1994 Hanson, A. et al., *Levels 2 and 3 External Events PRA for the High Flux Beam Reactor*, Revision 1, Prepared by Department of Advanced Technology, BNL, June 1994.

BNL 1995 BNL, *Future Use Plan,* BNL-62130, prepared for the U.S. Department of Energy by BNL, Upton, NY, August 31,1995.

BNL 1996a BNL, *Brookhaven National Laboratory Site Environmental Report For Calendar Year 1995*, BNL-52522, prepared for Department of Energy by BNL, Upton, NY, December 1996.

BNL 1997 BNL, *High Flux Beam Reactor Tritium Remediation Project Summary Report*, Draft Revision 2, prepared by Brookhaven National Laboratory, Lockheed Martin Idaho Technologies Company, Parsons Infrastructure and Technology Group, Inc. and Versar Inc., November 12, 1997.

BNL 1998a BNL, *BNL IHEM Program – Funding Balances and Returns*, BNL, Upton NY, March 17, 1998.

BNL 1998b BNL, *Reactor Division Electric Power KWH and Cost History*, September 15, 1998.

BNL 1998c BNL, *BNL 1996 Site Environmental Report*, BNL-52543, January 1998.

BNL 1998d BNL, *High Flux Beam Reactor Tritium Remediation Project, Summary Report*, March 1998.

BNL 1998e *HFBR Sanitary System Leak Test Report, November 1997*, dated January 30, 1998.

BNL 1998f BNL, *Draft HFBR Safety Analysis Report*, BNL, Upton, NY. February 1998.

BNL 1998i Kneitel, T., BNL Reactor Division Waste Coordinator, Memorandum regarding waste generated at the HFBR from 1992 through 1997, BNL, Upton, NY, October 30, 1998.

BNL 1999 BNL, *Brookhaven National Laboratory Site Environmental Report for Calendar Year 1997*, BNL-52553, BNL, Upton, NY, February, 1999.

BSA 1998 Brookhaven Science Associates, "Hazardous Waste Management Facility Description," BNL, Upton, NY, January 14, 1998.

DOE 1991 DOE, *Environmental Assessment for the Relativistic Heavy Ion Collider at Brookhaven National Laboratory, Upton, New York*, DOE/EA-0508, December 1991.

DOE 1993 DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, January 7, 1993.

DOE 1994 DOE, *Environmental Assessment for Programmed Improvements of the Alternating Gradient Synchrotron Complex at Brookhaven National Laboratory, Upton, New York*, DOE/EA-0909, March 1994.

DOE 1996a DOE, *Final Environmental Impact Statement for the Nevada Test Site and Off-site Locations in the State of Nevada*, DOE/EIS-0243, Volume 1, Part B, August 1996.

DOE 1996b DOE, Office of Naval Reactors, *Final Environmental Impact Statement for the S1C Prototype Reactor Plant Disposal*, DOE/EIS-0275, Volume 1, November 1996.

DOE 1997a DOE, *High Flux Beam Reactor (HFBR) Spent Fuel Transportation Plan (Revision 7)*, April 1997.

DOE 1997b DOE, *Final Waste Management Programmatic Environmental Impact Statement: For Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*, DOE/EIS-0200-F, May 1997.

DOE 1997c DOE, Office of Naval Reactors, *Final Environmental Impact Statement for the Disposal of the S3G and D1G Prototype Reactor Plants,* DOE/EIS-0274, Volume 1, November 1997.

DOE 1998 DOE, *Environmental Assessment for Proposed Booster Applications Facility (BAF) at Brookhaven National Laboratory, Upton, New York*, DOE/EA-1232, January 1998.

DOE 1999a DOE, *Final Environmental Impact Statement for the Spallation Neutron Source Facility,* DOE/EIS-0247D, April 1999.

DOE 1999b DOE, Office of Environmental Management, *Commercial Disposal Policy Analysis for Low-Level and Mixed Low-Level Wastes*, April 9, 1999.

EPA 1996 EPA, *Drinking Water Regulations and Health Advisories*, Office of Water, U.S. Environmental Protection Agency, Washington, DC, at URL http://www.epa.gov/OST/Tools/dwstds-s.html. Cited April 1998

ERDA 1977 Energy Research and Development Administration, *Final Environmental Impact Statement, Brookhaven National Laboratory, Upton, NY*, ERDA-1540, July 1977.

Hanford 1998 Hanford, Solid Waste Integrated Forecast Technical (SWIFT) Report: FY 1999 to FY 2046, 99.0, HNF-EP-0918, Rev. 5, 30 November 1998, at URL http://www.hanford.gov/docs/ep0918/index.htm.

Humphreys 1997 Humphreys, S.L., et al., *SECPOP90: Sector Population, Land Fraction, and Economic Estimation Program*, NUREG/CR-6523, SAND93-4032, September 1997.

IT 1998 *Draft Operable Unit V Remedial Investigation Report, Volume II of IV*, prepared by IT Technology Corp., March 18, 1998.

Kneitel 1999 Kneitel, T., *Waste Generation Data for the HFBR 1993-1997,* BNL, Upton, NY, January 1999.

Killough and McKay 1976 Killough, G.G. and McKay, L.R., *A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment*, ORNL-4992, March 1976.

NAS 1990 Committee on the Biological Effects of Ionizing Radiation, *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V*, Board of Radiation Effects Research, Commission on Life Sciences, National Academy of Sciences and National Research Council, National Academy Press, Washington, DC, 1990.

NRC 1999 NRC, *U.S. Nuclear Regulatory Commission Safety Assessment of the High Flux Beam Reactor at the Brookhaven National Laboratory*, February 23, 1999. At URL http://www.nrc.gov/OPA/reports/nrc.html.

NYSDEC 1998 Rommel, R E., Environmental Radiation Specialist, NYSDEC, *Letter to Chris Caperton, Energetics, Inc., responding to a request for information on radiological emission sources in the vicinity of BNL,* April 1, 1998.

Palmrose 1999 Palmrose, D. and Beaton, R., *Large LOCA Analysis of the BNL HFBR,* SCIENTECH, Inc., 1999.

Ports 1998a Ports, D., *Estimate of HFBR Water Consumption for EIS Alternatives*, Memorandum from Ports of BNL, November 5, 1998.

Ports 1998b Ports, D., BNL, *Personal Communications,* 1998.

Ports 1998c Memorandum from Ports, D., BNL to Files, dated October 29, 1998.

Ports 1998d Ports, D., BNL, *Personal Communications*, 1998.

Ports 1998e Ports, D., *CAP88 Analysis of HFBR 60MW Stack Release*, Memorandum from Ports of BNL, November 2, 1998.

Ports 1998f Ports, D., *CAP88-PC Analysis of HFBR Atmospheric Releases for CY 1990 and 1995*, Memorandum from Ports of BNL to M. Holland of DOE/BHG, December 31, 1998.

Ports 1999 Ports, D., *Personal Communications* 1999.

Reciniello 1998 Reciniello, R., *Radiation Exposure*, Memorandum from Reciniello of BNL, Safety and Environmental Protection Division, Upton, NY. February 1998.

Rorer 1998 Rorer, D., BNL, *Personal Communications*, 1998.

Schmidt 1998 Schmidt, E.R., *Revision of the BNL HFBR LOOP and Tornado Accident Core Damage Frequencies,* SCIENTECH, Inc., December 1998.

SNL 1990a Chanin, D.L., et al., *MELCOR Accident Consequence Code System (MACCS) Volume 1: User's Guide*, NUREG/CR-4691, Sandia National Laboratories, Albuquerque, NM, 1990.

SNL 1990b Jow, H.N., et al., *MELCOR Accident Consequences Code System (MACCS) Volume 2: Model Description*, NUREG/CR-4691, Sandia National Laboratories, Albuquerque, NM, 1990.

SNL 1990c Rollstin, J.A., et al., *MELCOR Accident Consequences Code System (MACCS) Volume 3: Programmer's Reference Manual,* NUREG/CR-4691, Vol. 1., Sandia National Laboratories, Albuquerque, NM, 1990.

Todzia 1998 Todzia, G., Personal communication regarding capacity volumes for waste management facilities, Waste Management, BNL, Upton, NY, August 11, 1998.

USGS 1998 National Earthquake Information Center, *US Geological Survey Earthquake Data Base, Search of Historical and Primary Data 1973- 1997*, US Geological Survey, 1998.

Wagage 1999 Wagage. H.A., *Calculation of Accident Consequences Using the MACCS Code*, SCIENTECH, Inc., December 1998.

WMG nd WMG, *Segmentation Brookhaven National Laboratory High Flux Beam Reactor WMG Report 9621*, prepared by WMG, Inc, Peekskill, NY, for BNL, Upton, NY, No date.